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TRANSACTIONS

OF THE

ROYAL SCOTTISH SOCIETY OF ARTS

VOL. XVIII.—PART II.

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THE EDINBURGH PRESS, 9 & 11 YOUNG STREET
1908

TRANSACTIONS

OF THE

ROYAL SCOTTISH SOCIETY OF ARTS.

VOL. XVIII. PART II

ON A DRAWING OFFICE CABINET FOR THE SUPPLY OF PAPER, ETC., FROM ROLLS.*

By JAMES GRAY, M.I.Mech.E.

RECENTLY the author had his attention directed to the waste of time and material, and the damage the latter sustained in cutting tracing cloths and papers from the roll; and was led to consider the advantage that would accrue in economy and convenience by the use of a cabinet designed for the supply of such goods in the Drawing Office. When designed it was found to be as convenient for the supply of "photo" and cartridge papers as for tracing cloths and papers.

The first cabinet made (that shown at the meeting of the Society) had the rolls carried on rods which passed through its sides, with a slot and cutting shelf for each of the goods being used; after a short experience these were found to be unnecessary, as two or more goods can be carried through one slot at the same time without the one having the least tendency to bring the others with it.

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* Read and illustrated before the Society on 25th November 1907.

The next point that presented itself was, "Why not use the cabinet for photographic papers also"? This led to a horizontal partition being put in the upper part and means adopted to exclude light from entering at the slot. This was effectually done by fixing a silk blind (M, Fig. 4) above the slot; on the upper surface of this blind the eccentric spindle acts. The "photo" papers are withdrawn between the blind and the cutting shelf, so that there is no waste of paper. Later it was found to be better to have a separate receptacle for "photo" papers and use them without rods, thus getting a perfectly dark chamber for the sensitised goods when in use, as well as an adjacent storage chamber G for stock; the top of the cabinet is removable, thus giving ready access to the "photo" papers.

Parts of the front member of the cabinet are made removable in a simple manner, thus making it easy to recharge with new rolls as such are required.

With the object of making cabinet suit different positions and requirements, it has been found advisable to arrange for different designs. Some of these are as follows:—

No. 1.—This, as shown by Figs. 1 and 2, is applicable for all-round work and all kinds of goods. It forms a neat part of any office furnishings. For papers 30 in. wide, the floor area occupied is 3′ – 0″ × 1′ – 1″.

No. 2.—A cabinet made in three sections, so that one or more of these sections can be used if desired for special purposes. For instance, the upper portion may be wanted by itself for "photo" dark room, the top section being arranged for sensitised papers only. Middle section carries all other roll goods. Bottom section forms a base for holding one or more drawers.

No. 3.—A cabinet arranged for the top of a table or desk. All the different goods come through a common slot, and have a common cutting shelf and eccentric spindle.

No. 4.—This arrangement is a modification of No. 3, for going underneath a desk or table.

There is no reasonable limit to the dimensions of the cabinet; for instance, it might be 4 ft. 6 in. height (that exhibited was 3 ft. 6 in.), and of width sufficient to deal with papers 60 in. wide or more, in which case a shutter (L, Fig. 4) takes the place of eccentric spindle.

DESCRIPTION OF THE PARTS AS SHOWN IN THE ILLUSTRATIONS.

A	Members forming front, back, and sides of Cabinet.
A^1	Removable portions of front to admit of easily recharging with new Rolls.
B	Drawers in bottom portion of Cabinet. Required only when no other means lends itself to the raising of Cabinet to a reasonable height above floor. This lower portion may be a hollow space closed in front and without drawers.
C	Slots for allowing free ends of Rolls to pass from the interior of Cabinet.
D	The Rolls of goods in middle portion of Cabinet.
D^1	Roll of Ferro-Prussiate paper in service.
E	Cutting shelves.
F	Eccentric spindle.
F^1	Journals of eccentric spindle.
F^2	Eccentrics (2) for lifting shutter (Fig. 4).
G	Storage for "Ferro" process papers.
H	Cover for hinged portion of A (Fig. 3).
H^1	Weight to keep edge of A^2 against spindle (Fig. 3).
L	Metal shutter $\frac{5}{32}$ in. thick (Fig 4).
L^1	Recesses in sides for ends of shutter (Fig. 4).
M	Blind, the use of which renders the hinged part A^2 (Fig. 3) unnecessary. The free end has a piece of rod attached which keeps blind flat and close to shelf (Fig. 4).
N	Brackets attached to shelf to carry eccentric spindle.
P	Handle for actuating the eccentric spindles.

REPORT BY COMMITTEE.

Your Committee met and considered the designs and construction of Mr Gray's Cabinet, and were also assisted by explanations of the parts by Mr Gray himself.

Your Committee are of opinion that this Cabinet is a very useful and necessary adjunct to a Drawing Office.

It is ingeniously constructed, and the methods adopted to store and serve out different kinds of drawing paper, and to protect "photo" paper from light exposure, are carried out in a simple and effective way, and ought to make the Cabinet not only a favourite, but also a material and time-saving appliance.

We desire to recommend it highly to the Prize Committee.

John Cran, *Convener.*
Alex. Clark.
John Smith.

ON IMPROVEMENTS IN MEANS FOR PREVENTING OR COUNTERACTING BACKLASH IN GEARING.*

By Dr James R. Milne, F.R.S.E.

The drawbacks due to the existence of backlash in the gearing of scientific instruments are too well known to require recapitulation. The usual way of attempting to overcome backlash is to fit the teeth of the various racks, wheels, etc., of the gearing into each other with extreme exactness. This, however, demands workmanship of the highest order, and hence is expensive. Furthermore, it does not afford a permanent cure, because in course of time wear takes place between the teeth, and their fitting consequently becomes less exact.

The author's arrangement—which is virtually equivalent to a form of wheel with elastically expanding teeth—is as follows:—

The smaller of the two wheels that gear together—or the pinion wheel in the case of a rack and pinion—is divided in half so as to make two wheels similar to the original one, although only half as thick. They are represented at *C* and *D* in the figure—the teeth not being shown. Both *C* and *D* continue to gear with the other wheel—or with the rack—as before. *D* is fixed to the axle *F*; the wheel *C*, the sleeve *E* and the arm *A* are fixed together as one piece, loose on the axle. The arm *L* is fixed on the axle. The effect of this arrangement is to force the two wheels *C* and *D* in opposite directions because of the tension of the springs *B*, *B*. Therefore, the corresponding teeth on *C* and *D* turn past each other until they completely fill up the spaces between the teeth of the wheel—or the rack—with which they gear; hence with this arrangement there can be no backlash.

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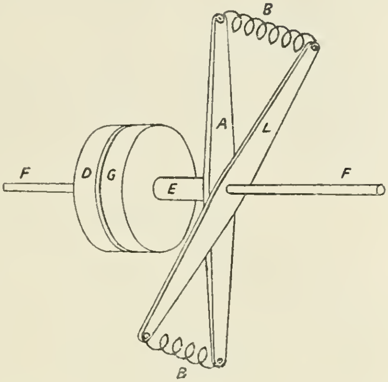
* Read and illustrated before the Society on 25th November 1907.



In the above device the drive in one direction is positive, in the other it takes place through the intervention of the springs, which, therefore, must be of sufficient strength to transmit the force of the drive without any yielding. The author finds that in the case of scientific instruments (to which alone application is suggested) this condition is attained without difficulty, a comparatively slight strength of spring being sufficient.

As the model submitted shows, this form of gearing runs very easily, and does not, like a close-fitted gear, have objectionable stiffness in working.

The chief advantages of the device are as follows:—

(1) It effectively cures backlash, and yet runs more easily than ordinary close-fitted gearing.

(2) Backlash does not make its appearance when the teeth of the wheels begin to wear, because the extra space between them is taken up by the action of the springs.

(3) The arrangement is inexpensive, since the teeth of the wheels that are used do not need to be very accurately cut, or to be ground together in order to give good results.

The author also wishes to state that he has had some practical experience of the device in connection with the rotating mount of a Nicol prism, and he has found it to answer admirably for this purpose.

REPORT BY COMMITTEE.

Your Committee on Dr Milne's method to prevent or counteract "backlash" has examined the model submitted to them, as well as the communication describing it, and are of the opinion that for scientific instruments or other exact purposes, when power is not the chief factor, that the means adopted to secure the absence of "backlash" are both ingenious and adequate, and believe there is a good field for its application.

Your Committee would point out, however, that for such exact purposes the teeth should always be machine cut.

Your Committee desire to recommend the invention to the favourable consideration of the Prize Committee.

John Cran, *Convener.*
James Gray.
Archibald Wilson.

THE MICROSCOPIC STRUCTURE OF METALLIC ALLOYS.*

By G. H. Gulliver, B.Sc., F.R.S.E., A.M.I.Mech.E.

It is about thirty years since the microscope was first employed in a systematic manner for studying metals. As was perhaps natural, the primary applications of this new method of investigation were directed towards the metals in everyday use, namely, cast iron, wrought iron, and steel. A certain amount of interesting information as to the minute structure of these metals was obtained, but the problems presented were soon found to be very complex, and in the light of present knowledge it appears that work was begun at the wrong end, and that an attempt was made to solve the most difficult questions before others considerably easier had been answered successfully. It is proposed to consider here, in a general way, some of the appearances presented by metals and alloys when examined under the microscope, and the causes which operate in producing their structure.

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* Read and illustrated before the Society on 27th January 1908.

To prepare a sample of metal for microscopic examination is not a difficult matter. It must be borne in mind that, though possible, it is quite impracticable to grind specimens so thin as to be capable of transmitting light; the time required is so great, and the character of the metal is so much altered by the process, that any observations which might be made would be valueless for most purposes. In the method generally employed a small piece, measuring about $\frac{3}{8}$ inch square and $\frac{1}{8}$ inch thick, is cut from the metal to be examined. One face of this is made as flat as possible with a file, and is ground by rubbing the metal gently on successively finer grades of emery paper, until the scratches left by one set of emery grains are removed by the next grade finer, and so on. Finally, the surface is polished by rubbing it on a piece of stout cloth, which has been impregnated with rouge or other polishing powder, and is stretched tightly over a block of wood, and kept moistened with water. The metal, when polished in this way, usually shows very little of its structure, and to make this clearly evident it is necessary to subject the bright surface to a chemical attack. The reagent to be used depends upon the kind of metal under examination, but the chief requirements for this etching fluid are that it shall act selectively, so as to differentiate the various structural constituents of the sample, and that its effects shall be moderately rapid. Mineral acids are employed frequently for this purpose, but any substance which has the required effect may be used. After the corrosion is considered sufficient—a point to be determined by experience—the specimen should be washed carefully, in order to preserve it from rust or discoloration.

Any microscope may be employed for the purpose of examining the metal, but the illumination cannot be by transmitted light, as in the case of biological and geological specimens. The light must be directed upon the polished surface of the metal, and reflected from this surface, up the microscope tube, to the eye. For this purpose a special appliance, called a vertical illuminator, is screwed into the end of the microscope tube just above the objective. The illuminator consists of a small brass cell, in which a glass prism or a thin glass plate is mounted on an axis, which is at right angles to the optical axis of the microscope; through an aperture in the cell a ray of light is directed upon the prism or plate, and by rotating this into a certain position the light is caused to fall vertically upon the specimen, from which it is reflected directly up the tube to the eyepiece. Under these conditions the brightly polished parts reflect nearly all the incident light, and appear very bright to the eye, while the corroded parts cause scattering to take place, and therefore seem relatively dull, since only a small proportion of the light incident upon them is returned to the eyepiece.

The surface of a pure or nearly pure metal, when prepared as described, and examined under the microscope, shows a number of small, irregular, polygonal areas, each of which is surrounded by a narrow, dark, boundary line. These polygons are the sections, made by the plane of the specimen, of the irregular polyhedral grains composing the mass. The etching fluid appears to have a greater action at the boundaries than in the interior of the polygons, and the boundaries therefore appear black; this is especially the case if the metal contains impurities. To understand why such a granular structure is obtained, consider the process of solidification of a molten metal. All metals in their usual state exist in a crystalline form, and generally belong to the cubic system; the crystals, most frequently, are either cubes or octahedra. Solidification of a liquid metal commences from a number of centres. A small crystal appears in the liquid, and others are rapidly formed in its immediate neighbourhood. The crystals, if cubes, adhere to each other by their faces, and, if octahedra, by their corners. In either case, since every small crystal has three axes of symmetry mutually at right angles, each aggregation grows outwards from its centre in three directions at right angles, but the directions of growth for each aggregation are quite independent of those for any other. The process of growth of the crystal aggregates is observed very easily, with the naked eye, upon the surface of a drop of melted tin or lead. Branches shoot out from the original nuclei and grow quickly in length; the parts first formed increase in thickness, and throw off smaller branches at right angles, and these throw off other right-angled branches. At length, the main branches proceeding from any centre meet those which have originated at neighbouring centres, and their growth is mutually arrested. The liquid which still remains in the meshes of each aggregate continues to solidify by the formation of smaller and smaller branches, until the whole mass is solid. Good specimens of crystal skeletons, showing this method of growth, may be obtained by pouring off the liquid parts from a partially solidified mass of metal. They are often to be seen in shrinkage cavities in ingots and castings, and assume a fir-tree form which is due to the manner of their formation. Since the original centres of crystallisation are distributed irregularly in the liquid metal, and the directions of growth from each centre are independent of those from other centres, the boundaries at which neighbouring aggregates meet are also irregular. An examination of a piece of tin-plate or of galvanised iron is very instructive in this connection.

Each of the irregular polyhedral grains of which a mass of metal consists is an aggregation of a large number of small crystals, which have true geometric forms, and are all similarly oriented in any one grain. Careful examination, under a high magnification, of a metallic surface which has been vigorously etched, shows evidences of these small crystals; the corrosion of the surface takes place in a definite manner, and small pits of geometric shape are dug out by the action of the acid. The surface of the metal shows a number of squares, triangles, or hexagons, all of which have their corresponding sides parallel within any one polygon. Sometimes the number of etching figures is very great, and they overlap each other in the manner of slates on a roof.

If a pure metal is melted with a small proportion of a second metal, the structure of the alloy when cooled is not very different from that of the original pure metal. The surface is again divided into a number of irregular polygons. If the second metal is easily soluble in the first, these polygons still have very fine boundaries, but if the mutual solubility of the metals is small, an appreciable space exists between the grains, and this is filled by a different substance which consists largely of the second metal. If the quantity of the added metal is relatively considerable, a marked difference in the structure of the mixture is observed, and a section shows crystallites of the first metal in a heterogeneous ground mass. The form of the crystallites shows that they are sections of crystal skeletons. When the plane of the section coincides with the axis of a skeleton, a corresponding fir-tree outline, with rectangular branches, is found on the specimen; crystal skeletons which have axes not lying in the polished surface are represented by rows of rounded dots. It would appear that solidification of the primary metal began in the same way as previously described, but that the amount of this metal was insufficient for the crystal skeletons to be completely filled in. The ground mass, if carefully examined, is found to consist of two distinct substances, which are mixed in such a manner as to show a fine banded or dotted structure; from the action of the etching agent, it appears that one of these constituents is identical with that forming the primary crystallites.

In order to understand why such a structure is found, it is necessary to consider the process of solidification more fully. If a pure metal is melted and allowed to cool slowly it begins to solidify at a certain temperature—its freezing point. Solidification continues while the temperature remains constant, and the loss of heat is balanced by the amount of latent heat evolved during the process; finally, when the mass is completely solid, the temperature again begins to fall. If a quantity of a second metal is added to the first, when in a liquid condition, it is found generally that the freezing point of the first metal is lowered, and that solidification is not completed at a constant temperature, but takes place gradually throughout a certain range of temperature. With two metals, A and B, if some of B is added to A the freezing point of the latter is lowered; as the metal A crystallises out, the relative proportion of B in the liquid part of the mixture increases, and the freezing point of A is lowered still further. Similarly, if a quantity of A is added to B the freezing point of B is lowered, and it continues to solidify at a decreasing temperature, while the proportion of A in the liquid increases. The compositions of the liquid parts of these two mixtures, therefore, gradually approach each other, and at a certain temperature are identical; at this point A and B crystallise simultaneously from the liquid, and the process of solidification is completed at a constant temperature, which is the same for all alloys of A and B. A mixture of the two metals, in the same proportions as they exist in the liquid at the lowest temperature of solidification, does not commence to solidify until this temperature is reached, and therefore has a lower freezing point than any other mixture of the two metals; it is called the eutectic alloy of the series. The section of a eutectic alloy shows it to consist, in general, of alternate laminæ of the two metals. An alloy of A with a less proportion of B than is contained in the eutectic consists of primary crystallites of A in a ground mass of eutectic, while if the mixture contains an excess of B this metal separates from the liquid until the eutectic solidifies. If the two metals, A and B, are completely insoluble in each other in the solid state, the eutectic is found in all mixtures of the series, and the alloys are formed of crystals of A or of B surrounded by more or less of the eutectic mixture. More often the metals are mutually soluble to a certain extent, and the eutectic is found only in mixtures of which the compositions lie outside the limits of solubility; for other compositions the alloys show the polygonal structure of a pure metal, and in cases where the solid metals are completely soluble in all proportions, all alloys of the series have such a structure. If the period of cooling is sufficiently long the primary crystals attract some of the small crystals of the same substance from the eutectic, so that when the proportion of eutectic is small, the final structure may show primary crystals of one metal in a ground mass of the other. Many examples of simple alloys of the kind just described are known, among them being the silver-copper, the gold-copper, the lead-tin, and the aluminium-zinc series.

In certain cases metals combine with each other to form definite chemical compounds. Thus, tin and magnesium form the compound $SnMg_2$. In such a case the structure of the various alloys may be understood if the complete series is considered as being divided into two sections, the first of which consists of mixtures of magnesium and $SnMg_2$, and the second of $SnMg_2$ and tin. Each of these sections corresponds with a series complete in itself, and there are two eutectic alloys, which are intimate mixtures of $SnMg_2$ with either magnesium or tin.

Other metals form much more complex alloys. Sometimes several different compounds are formed, but more usually these compounds are of a very indefinite nature. The alloys of greatest commercial value are the most complex in character, and the investigation of the alloys of copper with zinc, with tin, and with aluminium is attended with considerable difficulty. Of even greater complexity are the alloys of iron with carbon, and with manganese, nickel, and other metals. It is impossible in the short space at disposal to enter at all deeply into the nature of such mixtures. In some of these alloys remarkable changes take place at temperatures far below the point at which the metal became completely solid. If the mixture is cooled very rapidly these transformations may be prevented partially or wholly, and it is largely to this effect that the valuable properties of certain metals are due. The hardening of steel, for instance, is performed by heating it to bright redness and then quenching it in water; the hardening so caused is due partly, though probably not entirely, to the retention in the cold metal of a constitution which is normally stable only at a relatively high temperature.

ON RECENT DEVELOPMENTS IN MOTOR TRACTION.*

By The Right Hon. Sir J. H. A. MACDONALD, K.C.B., LL.D., F.R.SS. (L. & E.), M.I.E.E., Lord Justice-Clerk of Scotland.

THE last ten years have been made remarkable by the amazing development of mechanical traction upon roads, which it may be truly said is a thing unsurpassed in the history of the world. The wildest enthusiast would have hesitated ten years ago to predict that in 1908 there would be some 130,000 motor vehicles upon our roads, and that the power omnibus and the power cab would be rapidly superseding the horsed vehicle. When it is remembered that but a few years ago the motor vehicle was the butt of the gibing bus-driver and cabman, that it was declared

* Read and illustrated before the Society on 23rd March 1908.

in regard to it by opponents in the public prints that "nothing short of absolute prohibition would meet their just requirements," that it was jeered at as the cry of a few hair-brained enthusiasts seeking illegitimate pleasure, the change which has so rapidly taken place is nothing short of marvellous. I doubt if many people really even yet appreciate the extent of the revolution which is so quickly taking place. It may give some idea of it if I mention that there are already in this country twelve journals devoted to motor subjects, and that not a single journal which has been brought out has failed, which is proof positive that the motor trade advertising is remunerative. I counted the pages of one journal last week, and found that the advertisements sent in to it filled no less than 114 pages. Further, weekly and daily journals give up many columns to motoring news.

The streets themselves give emphatic testimony to this progress. I have ascertained by my own observation that in Edinburgh in the morning, when people are going to business, the number of private cars is greater than the number of private carriages. Taking twelve days, I saw in the morning 52 private motor cars and 21 private horsed carriages. In London the change is more marked, there being at least double the number of mechanical vehicles as compared with horsed vehicles every morning.* During a week the numbers on the Embankment from about twenty minutes to ten to half-past ten were 1,011 motor cars to 478 carriages. I remember well about eight years ago I used to note the number of motor cars on the streets in London, and was pleased to think that progress was being made if I saw six in a whole day. Now I should be surprised if I did not see at least six in five minutes, and twice that number of taxi-cabs in addition. Lastly, who would have believed that within ten years the sum of money represented by motor vehicles imported into or made in this country would have risen from about £600,000 to £3,500,000?

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* Since this paper was written the proportion has risen to at least 3 to 7.

Another current fallacy has been exploded. A few years ago it was the belief on all hands that the road locomotive could not be depended upon; the phrase "always breaking down" was on everybody's lips, and it was freely predicted that such vehicles would be found to be hopelessly expensive, as their life would be so short that they would prove much more costly than horsed vehicles. Natural enough as these ideas were, seeing that in the early days breakdowns were frequent, and many carriages soon found their way to the scrap-heap, they have nevertheless been negatived by facts. I can give an answer to both. My first car of 1901 carried me many thousands of miles. Being of an early type, I had many a stoppage, but never when I was driving did I fail to bring her home on her own power. My new car I have now driven for about two years, doing from 8,000 to 10,000 miles, and never have I been stopped for five minutes upon the road, and I know that my experience is that of others. The machine is a thoroughly trustworthy article, provided it receives fair play. Of course, it is easy to knock it to pieces in a year or two, just as an overdriven young horse will in a short year go in the wind and the legs.

Then, as regards durability, my old car is again an example. Of course, she is not made any better by age than I am myself, but in the country last summer, where she had lain discarded for a year, we happened to have to take both cars out. Well, with her six years on her head I drove her that day 89 miles, and, applying a horsey phrase, she "never turned a hair." Another interesting case of durability is seen every day in Princes Street, where these ten-year-old Daimlers are still running their 50 miles a day, doing 12,000 to 15,000 miles a year, when every horse on the Princes Street stands, at the time these cars began running, has gone to the knackers.

I am glad to say also that the fallacious idea that the motor vehicle is a luxury, and not a useful aid to the community, is exploded. I remember in this hall my friend Bailie Mackenzie criticised the power vehicle severely when I read a paper upon the subject. Well, two years afterwards I met him in a train and he asked me if I remembered what he had said. I braced myself to bear a fresh tirade, and replied, "Yes." "Well," said he, "I wish to recant all I said then: I have been using a car for some time in my business, and I feel now that I could not get on well without it." The other day the managers of the Bangour Asylum, by 22 to 4, passed an order for an autocar, the motion stating that it was "necessary for the proper working of the institution." Ten years ago people would have said that such managers should be detained in the asylum themselves. I notice, too, almost daily an ambulance autocar in front of the chamber of the Medical Officer of Health; and the Lord Provost has informed me that the paupers who are going to Craiglockhart travel by auto-carriage. Thus, from the king down to the pauper, the community is being carried in mechanically-driven vehicles, because those who can buy them do so, and those who have to use the rates for conveying lunatics and paupers spend them on autocars.

The power vehicle is also being largely used for conveyance of goods. The mails are carried for long distances, even in so wild a country as Sutherlandshire. So satisfactory have such services proved to be, that the Secretary of the Post Office informed me that the Department was about to establish a night mail between London and Dover—a distance of over 80 miles. This, if done by animal traction, would require five relays of horses, and could not be done under ten hours. In the same way the large warehouses of London—Whiteley's, Maple's, Shoolbred's, Harrod's and others—are using large numbers of delivery vans, and are adding to their fleets rapidly, finding as they do that they can cover a much wider range in less time than they could do with horses, which must be brought back to their stable after doing a very limited number of miles, the possible range being greater or less according to the state of the weather and the roads, while the motor vehicle can do the same distance in all weathers.

Thus the power vehicle has asserted itself for family, social, and sporting purposes, for business purposes, and for purposes of commercial transit, and nothing will now stop its progress. Those who have eyes to see the benefits it can confer, can only see this with unmixed satisfaction ; and those who still insist upon shutting their eyes, in blind hatred of the practical, will have to " dree their weird."

Such being the all-progressive position of road power traction, it is natural to expect that invention in regard to it should be stimulated. And I have thought that it might be interesting if some of the improvements were brought to notice, and that for two purposes : (1) of giving some indication of the progress that is being made, and (2) of showing how greatly invention has overcome difficulties, raising the power vehicle from the experimental stage to that of efficiency.

As regards the first part of the mechanism—the engines —there is not much to be said. Being of the gas engine type, their construction was not a novelty. The gas engine was a child of the early sixties of last century, and had been improved during the last forty years. In the autocar petrol is vaporised into gas and mixed with air, the explosive mixture thus produced being ignited in an engine which is practically a gas engine, and therefore familiar. In the ignition arrangements, however, great progress has been made. At first the ignition of the mixture of petrol vapour and air was effected by a platinum tube, kept hot by a lamp outside. That had two disadvantages. The lamps were not easily kept alight, and it was not possible to regulate the timing of the explosion. Now all motor engines are fired by electric spark. It may be safely said that sparking troubles are now rare, the makers of accumulators, magnetic coils, and sparking plugs having attained a high pitch of excellence in their wares.

Very great improvement has also been made in the carburettor, which is the chamber in which the petrol is vaporised by suction through a narrow orifice, thus providing the gas to be mixed with the proper proportion of air. It is a rare thing now to see a motorist turning wildly at his handle without result, his failure in the early days being generally attributable to the inefficiency of the carburettor. The spectacle of a crowd round a car, while its driver is doing a barrel organ performance for their amusement, is now a thing of the past. Ten years ago, when surface carburettors were still in use, there was nothing more surprising than to make a day's run without some trouble in the carburetting and ignition departments; now such an event is of itself a surprise. Such a thing has not happened to me in 10,000 miles of running.

There has also been great improvement effected in the working of the inlet valves by which the mixture passes into the cylinder. Formerly the valve was opened by the suction of the piston as it was drawn up to take in the mixture. This was a somewhat primitive device, and the tension of the valve spring could not be adjusted with certainty; the action of the suction in opening the valve was thus not uniform, and any stickiness of the valve tended to prevent its opening promptly. Now the opening is effected by cams on a revolving shaft, acting in exactly proper timing.

The prevention of overheating of the engine is also more thoroughly effected. The old air-cooling is now no longer used, except in the small engines of motor bicycles, and the cooling is effected by water.

Turning now to the communication of the power to the driving wheels, there are two modes in which this is accomplished. In one the power is transmitted to sprocket wheels of small size, and from these by chains going over a sprocket wheel of larger size upon the driving wheels. In the other the power is conveyed to the hind wheels through the axle, by bevel gearing. The contest is somewhat hot between the systems. The tendency seems to be towards the opinion that for heavy cars the chain drive may be the best, while for lighter cars the live axle drive may be satisfactory and save complication.

This view is, I think, sound, but I lean to the chain drive for all but the smallest cars. It is obvious that the driving mechanism must be exposed to violent strains, that sometimes it must bring things near to the snapping point. It cannot but be an advantage to have in the sequence of communication between engine and wheels one flexible part which can yield to stresses that act unevenly. Such a medium is a chain without lateral rigidity, and capable of stretching without reaching the breaking point. This seems preferable to a system in which every part between engine and wheels is rigid and inflexible, and which must therefore wear the surface of the teeth of bevel wheels rapidly, thus tending to bring down the axle in the centre, and put the wheels off their parallelism to one another. And given great strain, there is every advantage in its exercising its destructive effect on a chain which can be replaced in a few minutes, rather than on a shaft, which, if it gives way, involves an absolute stoppage, and a heavy bill for repairs. It is this view which had influenced many Continental manufacturers to turn back again to the drive by chain.

One objection to the chain drive was its somewhat noisy character, but this is in large measure overcome by improvements in the chains, and also by enclosing the chains in a bath of oil.

Again, as regards the heavier vehicles carrying large loads of great weight, I show you some links of the Renold chain, which is now largely in use for omnibuses and waggons, and in which the arrangement greatly modifies friction.

I now come to one of the most important matters connected with the driving of an auto vehicle, consisting of two parts, (1) the clutch by which when the engine is running the driving mechanism is put in communication with the engine shaft, (2) the means by which the motion can be regulated to effect the proper ratio between the speed of the engine and the speed of the wheels, so as to obtain speed when the engine power can be fully used for that purpose, or to obtain extra power where speed cannot be kept up, as when ascending a hill, or driving through clogging or rough ground.

I take these two matters together, because in the evolution which has been going on the two are closely associated. Time does not permit that I should speak of the many forms of clutch. The general form is that of a blunt cone which is brought into contact with a corresponding saucer-like depression, and thus by friction between the two the motion is conveyed to the driving shaft. The keeping of the face of the clutch in such condition that to act sweetly, and not, as we say, fiercely, is one of the problems. But a plain leather face, kept in proper order, is found to be wonderfully efficient. Multiple discs and metal to metal faces have their advocates, but there is not much room for great improvement in this department, unless it be in the application of magnetism as the holding power.

Turning to the speed-changing arrangements, these consist of cogged wheels of different sizes, each pair of which can be brought into mesh as desired by the wheels being moved along the shaft, thus at one time accelerating by driving a small toothed wheel by a large one, or lowering the speed and multiplying power by a smaller wheel driving a larger one. This, though mechanically a sound method of changing speeds, is a most undesirable mode in the case of a machine that is to be knocked about and jolted over rough roads. The loss of power in the transmission is great, the wear on the teeth tends to the running becoming less smooth, and for this there is no remedy; a new set of gears is the only cure. If the day comes, as I think it is coming, when motor cars are run without trains of wheels being constantly changed by pulling one out of mesh and thrusting another in, we shall probably look back upon our present gear-box as a box of very primitive tricks indeed. And this is particularly the case when motor traction is applied to heavy vehicles, such as omnibuses which have to be constantly stopped to put down and take up passengers. The frequent starting by the clutch, and the constant changes of gear, so as to get power to start, and again to get speed to run, tend to shorten the life of the vehicle, and to make its running unpleasant and noisy.

It is in this department that there are signs indicating that magnetism is likely to play a prominent part in the development of a better system. I can only tell you that magnetism is applied for starting, for clutching, and for speed control. When the engine is to be started the battery of accumulators drives a motor which sets the engine revolving, the motor thus effecting what is now done by hand when starting. Whenever the engine is started and is running by its own explosions, it overcomes the motor, and drives it, thus converting it into a dynamo, and refeeding the accumulators with energy. The driver, when he desires to move his vehicle, does so by a magnetic clutch which he can charge so gradually that the start is smooth and not jerky. Instead of the faces of the clutch being forced together to produce a friction hold, electricity is allowed to pass round insulated coils of wire wound on to the clutch, which thus while the current passes becomes a powerful magnet, causing the faces to hold together. Another advantage is that the clutch is put into and out of action by the touch of a finger, instead of by forcible pressure on a stiff pedal. The arrangement dispenses with any gear-box with toothed wheels.

I had hoped to be able to give you illustrations of a system, which is called by the somewhat fantastic title of the Automixte system. But my friends of the Daimler Company who are working out the construction have felt compelled, for business reasons, to go back upon their kind intention to supply me with slides for the screen. When the vehicle is from any cause checked in speed, as when ascending a hill, there is no gear-changing required to give more power. The speed falling, the accumulators resume their function to give out power, and reconverting the dynamo or energy producing action to motor or energy delivering action, assist the power of the engine and maintain the necessary speed. When descending a hill, on the other hand, by cutting out the power of the engine, the electric power can be used for magnetic braking purposes. So far as I can judge, this system seems to have in it every promise of success.

Another clever device by the use of magnetism I am able to show you by the kindness of Messrs Middleton and Townsend. Here gears are still used, but they are not changed by one set being unmeshed and another meshed. They all remain in mesh, but each has a clutch of its own, worked magnetically, so that the wheels do not revolve, except those of the particular set which the clutch is made to hold by being magnetised. As regards such vehicles, the introduction of a system similar to those I have referred to, by which changes of speed are made by the use of electrical appliances, would, if it be proved practical, be of great value.

Great progress has also been made in the production of efficient vehicles for conveyance of goods. Here, again, the question of cost of transit per mile has been solved favourably for the power vehicle.

In this department also there are likely to be important advances. One of these is highly interesting, namely, the road train of Colonel Renard of France. And this is doubly interesting, because it has a great bearing upon the wear and tear of roads by heavy vehicles. Colonel Renard's train is unlike any other in that, although his three or four vehicles receive their power from one engine in the front vehicle, those behind are not dragged by it, but the power is communicated by it to each vehicle behind by a shaft, so that each is separately driven by its own road wheels. And by an ingenious arrangement, which I cannot stop to describe, each vehicle follows in the track of that in front of it, so that the train can be moved round corners, or manœuvred in a circle, which it would be quite impossible to do with trailers attached by drawbars. But the paramount advantage claimed is that the goods being distributed over several vehicles instead of piled on one waggon, the wear of the road is not nearly so great as it is when one set of wheels has to do the pushing for the whole weight to be moved,—which has double disadvantage, first, that the front vehicle must have great weight to give the necessary adhesion to the road ; and, second, that the whole force for moving the weight being on two wheels only, the attack on the road surface is greater, and more severely damages the surface.

The last, and probably the greatest, problem with which invention has been struggling is the part of the vehicle which touches the road, viz., the wheels. As regards the wheels themselves, there is war between the votaries of the wooden artillery wheel and those of the wire wheel. They are both good wheels, and the wire wheel has some advantages, including lightness and ease of repair. Time will prove which is best.

But whatever wheel is used there can be no doubt that it is in the wheel and its tyre that most of the remaining troubles of the motorist centre. The improvement in pneumatic tyres has been extraordinary, but still you never can be sure that a nail or a piece of glass will not suddenly compel you to call a halt, or that a tyre after it has been used for a considerable time will not suddenly be burst outwards by the pressure of the tube at a weak place. Well, there are cures and there are palliatives. As regards punctures, there is the device which is called by the bold name of *miraculum*. It consists of a liquid put into the tyre in sufficient quantity to spread over the inner surface, with the result that when a puncture takes place the miraculum is forced by the pressure into the hole and seals it up. If this really proves to be a success it will be an unspeakable comfort. I am not able to demonstrate its use, as it requires for success that the weight of the carriage should be upon the wheel, but I have a letter from Mr Budford, manager here at 16 Shandwick Place, for "Argylls Limited," saying that they have a miraculum-lined wheel in their premises at Shandwick Place, and that they will be glad to show it to any one calling there. Another similar appliance is called *elasticum*, but I have had no opportunity of testing either.

Of palliatives there are many. The Stepney wheel is one of these, and I show you a specimen of it. When a puncture or a burst takes place the Stepney wheel is made fast to the spokes of the wheel, and thus the vehicle is provided with an auxiliary wheel for the time being. Later still, spare wheels have been provided with ingenious arrangements by which in a minute or two the damaged tyre can be removed and another substituted. I have known the fight to get a new stiff tyre on last for much more than an hour, so that a detachable system must become popular, if efficient. Further still, there is now a device by which a tyre and tube fully inflated can be carried as a spare and slid on to the circumference of the wheel. For the repair of burst tubes and tyres there are many devices. Messrs Harvey, Frost and Co. have lent me a handy vulcaniser, which I show you in its compact and neat form. By it the motorist himself can make excellent repairs.

The elimination of road shocks, by which vehicles, machinery, and passengers are rudely shaken, has been made the subject of study, and with considerable success. I show you here a device of Mr Fulton of Paisley, by which, with the aid of springs, he prevents the sudden action of the springs of the carriage when they have been pressed down, and causes the resumption of the ride upon the springs to be gradual, and also by an ingenious arrangement controls the swaying motion when making turns. My friend, Mr Andrew Reid of the Clyde Locomotive Works in Glasgow, assures me that with this device the motion is not different on a roughly-paved street from what it would be on a good macadamised road.

Here is another and ingenious device kindly lent to me by my friend, Mr Siddeley of the Wolseley Company, in which oil is used. As the carriage goes down upon the springs, the oil passes from one position to another through vanes which are open. Whenever the springs begin to ascend again the passage is closed, and the oil can only return through a narrow by-pass, the resistance thus caused checking the speed of the reverse motion of the spring.

There can be no doubt that such appliances as these will be likely, if successfully designed, to add greatly to comfort.

Further, there is the problem of side-slip. I have myself seen a car describe more than a complete revolution before it came to rest, and in such a case a driver is quite helpless. Against this there are now many devices. One which I use myself is the Parsons chain, of which I show you a specimen. It is efficient, if care is taken not to use brakes, when a sliding tendency shows itself, but only taking out the clutch so as to remove the power. Many use studs fastened into the tyres, and they are efficient, but are rather destructive of road surfaces.

One of the latest devices is by Mr Kempshall, of golf ball fame, and I show a specimen of his invention. I am assured on good authority that this tyre, with its air pockets, admits of a car being driven on most skiddy ground without any sign of deflexion.

Lastly, there is a motorist's bugbear, when a tyre tube has to be replaced on the road, and that is the hard and long work of pumping to bring the tyre to the proper air pressure for good running. To relieve the motorist from this labour the Parsons Company provide a case of compressed carbonic acid, which I show you, and which can be stowed on the car. When inflation is necessary, a tube from the case is attached to the tube valve, and the tube is at once inflated to the proper pressure by the gas.

(A number of illustrative slides were here shown.)

Ladies and Gentlemen,—I said at the beginning that sensible people must look at road power traction in the light of facts, which make it certain that it is already taking the place of animal haulage in a substantial degree, and, therefore, as it is making its way steadily into the daily life of the community, whether for travelling or commercial transit, it will be well for all of us to know something about the matter. My purpose has been two-fold—to give some information, although, of course, it could only be of a general nature, and to interest you in a great new development in locomotion by which speedy and convenient transit will be furthered, which has been the result already; and must have greater result yet of benefit to society, great relief to congested town population, and incalculable advantage to agricultural and commercial progress, and—may I add?—in my own opinion, additional security of great value to the national defence of our country.

ON ARSENIC-FREE GAS-COKE.

By HENRY O'CONNOR, F.R.S.E., and DR THOS. W. DRINKWATER, F.R.S.E.

ABOUT the middle of 1901 a Commission of experts, consisting of the following—Sir Lauder Brunton, Dr Stevenson, Mr Alfred Gordon Salamon, Dr Luff, Dr Samuel Buckley, and Mr J. Fletcher Moulton, K.C.—were appointed by the Manchester Brewers' Central Association, to investigate the causes of poisoning by beer. The section of their report referring to Coke reads as follows:—

"When malt is contaminated with arsenic, the malt culms and kiln dust contain a much larger proportion of arsenic than the malt itself. This is accounted for by the fact that, when the green malt is loaded on to the kiln, and subsequently during the kilning, the physical structure of the culms renders them particularly liable to absorb any arsenious vapour that may be carried to the malt as the result of combustion of contaminated fuel, and that this liability is increased by the fact that from their position, relative to the malt, they are more exposed to the heated air. Our investigations have shown that the contamination of malt culms and kiln dust is chiefly due to the use of coke, and especially of gas-coke. Enquiries made of the principal maltsters in England have elicited the practically unanimous opinion that there is no necessity whatever to employ gas-coke in the preparation of malt. Nor, indeed, is there any real necessity to employ coke at all for the purposes of malting. If the use of coke were dispensed with, a good many malt kilns would have to be structurally modified, but the brewer would not fail to appreciate the benefits of such alterations. It might be necessary to use a small portion of coke in the drying of amber malt, but in such cases it would certainly be advisable to employ coke made from hand-picked and washed coal, and not gas-coke. We recommend, therefore (1) That the maltster be required to give a guarantee to the brewer that he does not employ gas-coke in the preparation of his malt. (2) That the malt culms be regularly tested for the presence of arsenic. (3) If the culms be found to contain noticeable quantities of arsenic, that the kiln dust be at once removed, and the fuel employed be further examined for arsenic. That, wherever possible, the best anthracite be employed for malting purposes."

That there was every reason for the appointment of the Commission is evident from the fact that there was exceptional sickness and death at the end of 1900 attributable to arsenical poisoning, chiefly affecting the districts in Lancashire and Staffordshire. Manchester suffered most, the number of cases in the county boroughs of Manchester and Salford alone being put at 3,000. It was not until November 1900 that arsenic was indicated by Dr E. S. Reynolds of Manchester, as the cause of the epidemic sickness in the city. The beer then in consumption was tested, with the result that arsenic was found in dangerous proportions in a large number of samples. When the beer was withdrawn from sale, the epidemic came speedily to an end.

At the beginning, the arsenic scare was founded, not upon the amount in the coke, but that in the sugars used. It was, however, noticed that there were other sources of contamination with arsenic, and these were principally due to the fuel used in drying the malt, which at that time consisted largely of gas-coke; one firm of maltsters in Harrogate taking about 3,000 tons yearly, and this use of coke had to be entirely abandoned at that time. It was the knowledge of this fact that led to our experiments to eliminate the arsenic and to again make this fuel satisfactory for malting purposes. Lime was first tried, with the result that the arsenic was rendered non-volatile and fixed in the coke. This did not get over the difficulty, as the coke dust in the kiln contained arsenic, which, it was pointed out in the report, was objected to, as it plainly indicates that the kiln dust is a source of contamination. At this point it might be mentioned that the amount of arsenic found in coal and coke is not large. Another point which might be noted is that the arsenic found in the original coal is nearly all left after carbonisation in the resultant coke, showing that the usual process of retorting has little or no effect in reducing this impurity.

From tests we have made we give the following:—

Quantities of arsenic as arsenious oxide found in coals and cokes. Results in grains per pound:—

No. 1	1.03	Scotch Coals.
No. 2	0.98	
No. 3	0.99	
No. 4	0.76	
No. 5	0.88	English Coals.
No. 6	0.98	

No. 7	0.02	Welsh Anthracite.
No. 8	0.86	Gas-Cokes (ordinary).
No. 9	0.74	
No. 10	0.65	
No. 11	0.91	

It seemed, therefore, that some method of volatilising the arsenic during the process of manufacture of the coke would be the best, if not the only way, of solving the difficulty. Hydrochloric acid was passed over hot coke, which was found to completely eliminate the arsenic. It was obvious that this process could not be used on a manufacturing scale on account of expense and corrosion of any metal work, but it afforded a clue as to the method likely to succeed. We therefore turned our attention to volatile chlorides, which would themselves provide the chlorine gas required to combine with the arsenic and form a volatile compound.

Experiments on a small scale with common salt were successful, but not to the extent that was found with the hydrochloric acid. We then had an opportunity of trying the experiment on a manufacturing scale in the vicinity of Edinburgh. A rough calculation of the amount of salt required per ton of coal showed that 2 oz. would be ample. This was allowing for a considerable loss in salt which was bound to occur. The result showed that whereas the coal contained 1.66 grains $As_4 O_6$ per lb., the coke prepared in the laboratory from that coal untreated gave 0.83 grains $As_4 O_6$ per lb.; while the coke from the same coal, but treated with the salt at the gas-works, gave 0.0055 grains per lb. only. "This, although more than good anthracite coal contains, is, of course, infinitely better than gas-coke averages, and about the same as oven coke of the best type." This was the opinion of a practical maltster. We might point out that the figure given — namely, 0.0055 — was the total arsenic present, both fixed and volatile. It was pointed out to us that it would be necessary in future work to distinguish between the fixed and volatile forms. It occurred to one of us that a more intimate mixture of salt and coal, and one which would be more easily applied, would be obtained by sprinkling the coal with a solution of salt in the proper proportions. An experiment on these lines was carried out in the gasworks with the following results:—

Coal	0.99	grains As_4O_6	per lb.	
Coke	0.0057	,,	,,	volatile
,, ...	0.002	,,	,,	fixed
Total . . .	0.0077	,,	,,	

These results were somewhat disappointing, and we think are accounted for by the moisture carrying off some of the salt before it had acted on the arsenic. We therefore returned to the use of dry salt, and at this stage it was thought advisable to send duplicate samples to a brewing chemist, and the comparative results were as follows:—

Untreated Coke	A	0.0357	volatile
,, ...	B	0.04	,,
,, ...	A	0.0143	fixed
,, ...	B	0.014	,,
Treated Coke	A	0.0024	volatile
,, ...	B	0.003	,,
,, ...	A	0.0143	fixed
,, ...	B	0.012	,,

As regards the series of analyses marked "A" of the treated coke, the chemist reported: "This coke was about the average of the best anthracite."

A further experiment was now tried as to the effect of a mixture of lime and salt sprinkled over the coal before retorting, using 8 oz. of each to the ton of coal. The results as found by the brewing chemist showed:—

Untreated Coke	A	0.007	fixed
,, ...	A	0.013	volatile
Treated Coke	A	0.012	fixed
,, ...	A	0.002	volatile

This shows that the fixed arsenic is slightly increased, while the volatile is considerably decreased. The use of the mixture showed no improvement over the use of plain salt, in fact the fixed arsenic appeared to be increased. Being anxious to try the effect of other chlorides, we substituted calcium chloride for the salt in another experiment with the following results:—

Untreated Coke	0.013 fixed
„	0.067 volatile
Treated Coke	0.016 fixed
„	0.011 volatile

We now submitted samples of our treated coke made in the gasworks, with the use of salt only, to Dr A. K. Miller of Manchester, an accepted authority on arsenic in coke (without giving him any information as to the origin of the coke), and his report states:—"I have carefully tested for arsenic the sample of coke received from you on the 8th inst., and I find that it contains approximately:—

"Total arsenic calculated as arsenic tri-oxide $\frac{1}{35}$th of a grain per pound.

"Volatile arsenic *nil.*" ($\frac{1}{35}$th of a grain is practically 0.028.)

On informing Dr Miller of the origin of this sample, he again wrote:—"If the coke was originally anything like the samples which I am in the habit of analysing from this district and Yorkshire, your treatment of it has certainly had a remarkably purifying effect."

The patent was applied for and granted entirely free from any qualifying clause or reference to previous patents. The process is now in operation, and, in the case of one company using it, supplies of treated coke have been furnished at least nine times to the same firm of maltsters over a period of two months, which clearly shows that such supplies were giving satisfaction. The tests for arsenic are among the most delicate in analytical chemistry, the very small quantities to be dealt with precluding the possibility of weighing. At the time of the arsenic scare, a number of methods of estimating small quantities of arsenic were proposed. As our investigation required the most accurate results and involved considerable numbers of analyses, it was necessary that the process selected should be at the same time both accurate and quick. One of the earliest methods recommended was to treat the coke with strong nitric acid on a water bath and to evaporate until the red fumes ceased. The residue was then treated with concentrated sulphuric acid in a similar manner twice, and the extract Marshed in the usual manner. The repeated evaporation took considerable time, and, as far as our experience went, was liable to contain sulphides which would retain some of the arsenic.

After the Royal Commission had issued their report, the Chemists of the Inland Revenue Department were asked to prescribe a process applicable to all substances used in brewing operations, and, after trying a number of experiments in the Government Laboratory, Professor Thorpe laid before the Chemical Society in 1903 a very complete set of tests for the examination of brewing materials for arsenic.

The only one which interests us this evening is that portion of the report which deals with fuel. A special apparatus was designed in which all the glass parts fitted together with ground joints. The process consisted in heating the fuel in a current of oxygen and collecting the volatile constituents in a vessel filled with arsenic-free acid. The acid liquid containing the volatile arsenic was at once Marshed, and the result gave the volatile arsenic. The residual ash containing the fixed arsenic was treated to a rather complicated process. It was placed in a flask attached to an inverted condenser, and boiled with pure hydrochloric acid containing a little bromine. It was boiled in this for two hours; it was then allowed to cool, and the excess of bromine removed by means of meta-bisulphite of potash; the liquid was next boiled to expel the sulphur di-oxide produced, and afterwards filtered. The clear filtrate was distilled, and the distillate contained all the fixed arsenic in the form of chloride.

It was now evaporated down with a mixture of nitric and sulphuric acids until the fumes of sulphuric acid appeared, then it was cooled and diluted. As the arsenic was at this time in the condition of higher oxide, it was not suitable for Marshing, and the arsenic was therefore reduced by means of meta-bisulphite of potassium and the excess of sulphur di-oxide boiled off, the residual liquid Marshed in the usual manner.

This process, although very complete, and undoubtedly capable of giving good results, is open to several objections. In the first place, the heating in oxygen takes at least two hours, and the remainder of the process about another four or five. Again, in the case of coal, the heating in oxygen is liable to end in an explosion unless great care be taken. The next method proposed was to heat the coal or coke with a mixture of magnesia and dry sodic-carbonate; the residue was dissolved in sulphuric acid and Marshed as in other methods. The magnesia and sodium carbonate in this process retain the arsenic, which is afterwards dissolved in the sulphuric acid.

The success of this process depends mainly, on firstly, the fine division of the fuel, and, secondly, on the gradual heating of the mixture in the crucible. Proceeding in the manner described it was found sometimes, for reasons which we cannot explain, that the residue contained sulphides; and although this method has in the main been used, it has been found convenient to add to it some portion of Professor Thorpe's process.

After heating with magnesia and soda carbonate, it is dissolved in purified hydrochloric acid and bromine, and boiled under the inverted condenser as formerly described; the remainder of the process is conducted as in Thorpe's method. The difficulty in all these methods is to procure pure chemicals free from all traces of arsenic. This difficulty was recognised by the Royal Commission, and they give a method of purifying the hydrochloric and other acids used. There is not so much difficulty now as there was at the time of the Commission. Pure zinc can be procured, but one must select the sample, as some forms of zinc are insensitive for some reason not at present known. The somewhat cumbrous method proposed by the Royal Commission for the purification of the acid has been given over, and it is simply boiled under a reflux condenser with some copper gauze for two hours, and then, after removing the gauze, distilling the acid; in this way the faintest trace of arsenic is removed.

In using pure zinc in the Marsh apparatus, one frequently finds that the acid has little or no action on it, and this difficulty is best overcome by adding a few drops of strong solution of sulphate of copper, when the action at once commences.

The increasing prices of anthracite coal, due to its use for malting and in the suction power gas-plants, renders the question of another fuel one of considerable importance to maltsters. The number of letters which we have received asking particulars of the process show that the maltster is quite prepared to return to the use of coke if this can be rendered non-arsenical.

REPORT BY COMMITTEE.

The Committee have duly considered the above Paper. At the outset they do not feel they are called upon to express any opinion as to the validity of the Patent, although as far as they have been able to enquire they cannot trace any previous written or printed provisions of the nature that forms the subject of the Paper.

For many years gasworks coke was used for malting purposes, but early in the 1900's a great scare arose in consequence of the presence of arsenic in beer, particularly in the Manchester district. It was primarily due to the accidental presence of arsenic in the glucose used in the manufacture of the beer, but traces were found to be given off by gasworks coke, etc. This necessarily resulted in the abandonment of gasworks coke for the purpose throughout the country.

The writers of the Paper claim that by the simple process of adding a small percentage of common salt, proportionate to the amount of arsenic in the original coal, previous to carbonisation in a gasworks, the effect is to act upon the arsenic in such a way that the greater proportion is vaporised, and that when the coke is used for brewery purposes no arsenic is evolved, and, so far as the Committee are able to determine, the claim appears justified and substantiated.

The process has not long been in use, but so far as it has been it is established that where coke so treated has been used in breweries in the Wakefield district, no complaints have arisen in consequence of volatile arsenic being given off by gasworks coke so employed.

A member of the Committee suggested that the treatment of the coal by the means proposed might result in the arsenic being volatilised and going forward with the coal-gas, and thus being objected to by gas manufacturer and consumer. The Committee, however, are assured by both Dr Drinkwater and Mr O'Connor that the arsenic would be removed in the normal process of scrubbing the gas, and that should by any possibility the arsenic pass forward from this apparatus, then the purifiers would remove all final traces.

The commercial effect of the treatment is important, as it makes it possible for brewers to use the local gasworks coke for malting purposes, which results in considerable economy in the cost of the fuel used, and on the other hand it provides an important outlet at a reasonable profit for the local gasworks output of coke.

Your Committee believe the process to be a useful and practical one, and have pleasure in recommending this communication to the favourable consideration of the Prize Committee.

W. R. HENNING.
EMIL WESTERGAARD.
G. H. GEMMELL.

ON DIRECT COLOUR-PHOTOGRAPHY BY THE LUMIÈRE PROCESS.*

By Edward Lumsden Brown.

On examining with the stereoscope any of those interesting photographs, in which form, proportions, distances, and even the intervening air between the various planes are rendered with such perfect accuracy, one often says, "Colour only is wanting." This is a desire which can now be satisfied. Colour-photography has been discovered, and found to be practicable.

To understand the new process, one must keep in view the fact that all colours are but combinations of one or more of the seven colours of the spectrum, composing white light, viz.: — violet, indigo, blue, green, yellow, orange, and red. Every colour possesses what is called a complementary colour, which, placed side by side with it, makes it appear more brilliant. For example, blue has for its complementary orange, yellow has violet, red has green. Indigo—intermediary between violet and blue—has for its complementary an intervening colour between yellow and orange; and, as to the shades, their complementals vary to the infinite. Moreover, these seven colours can also be reduced to three primary ones —namely, violet-blue, green, and red, the mixtures of which give all the colours imaginable.

The author, after having first explained the "three-colour" process, proceeded to describe that of Messrs Lumière.

After long and arduous trials Messrs Lumière have fixed their choice upon potato starch, a transparent medium, well divisible and easily coloured. This must be finely pulverised, passed through a sieve, so that not one of the grains of starch is bigger than a ten-thousandth to a twelve-thousandth millimetre in diameter. One part is dyed green, another orange, and a third violet. These three powders are mixed, then sprinkled on a plate coated with a glutinous and transparent preparation. A special handling is required to avoid all superpositions of the grains, after which the plate is passed to the flatting machine, which flattens the grains in order that there may be as little space between them as possible. These spaces are filled in afterwards with the aid of lamp-black. Examined under a microscope, the plate has then the aspect of a sort of tricoloured mosaic, resembling transparent confettis or stained glass windows, the lead of which is represented by the lamp-black. On that mosaic is spread a layer of impermeable varnish, then a layer of gelatine bromide of silver, rendered panchromatic—*i.e.* equally sensitive to all colours—and the "autochrome plate" is ready for use. It is placed in the dark slide the reverse way to an ordinary plate, so that the light can only reach the sensitive film after having gone through the coloured starch grains.

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* Extracted from paper read and illustrated on 13th January 1908.

On a square millimetre area of a plate there are between eight thousand and nine thousand of these grains coloured in green, orange, and violet, and which themselves constitute as many screens of the same colours interposed between the model and the sensitive plate. Owing to the microscopic dimensions of the constituents of these screens, their effects are blended, thus producing upon the eye the effect of a uniform coloration, when in reality there are an infinite number of minute greens, orange, and violet plates, every one of these plates being represented by one grain of starch. Assuming the instructions of the "three-colour" process have been carefully followed, it will be understood that the "autochrome plate" once impressed, developed, and fixed, will give, not the coloration of the subject, but its complementary colours, seeing it is a negative at this stage. To obtain the positive, instead of fixing our negative after the first development with a solution containing Pyrogallic acid and ammonia, the plate is passed into a solution of acid permanganate of potash, then brought into broad daylight, where a second development takes place with diamidophenol, the effect of which is to transform the negative into a positive with the real colour of the subject. Take one detail, for instance, in a portrait made by the author. The reproduction of the mouth in the part of the sensitive layer, situated under the green grains of the plate, the red rays, emanating from the lips, have been absorbed by their complementary, and have not been able to reach and impress the silver salt, while those in the parts situated under the orange or violet grains have been able to pass through and sensitise the gelatine bromide. A negative of the mouth is thus obtained. The first development being finished, the negative is put into the acid permanganate bath, which dissolves the reduced silver under the orange and violet grains, and leaves untouched the unacted-on silver under the green grains. At the second development the diamidophenol blackens the unacted-on silver, thus darkening the parts of the plate situated under the green grains. We only see the orange and green grains with thousands of microscopic points of which the intimate mixture, to our eyes, give the red. So it is for other colours. The operations of intensifying, toning, etc., were also described in detail.

This important discovery honours the discoverers and French science. As a whole, it forms a memorable epoch in the history of photography.

Messrs Lumière have placed in our hands the means by which an amateur photographer of ordinary intelligence and ability can now reproduce any colour or shade whatever direct on one plate by one exposure. That is to say, that which could only be done by the "three-colour" process, either in printing or photography, can now be accomplished in one operation by exposing one plate on the object in place of three, and, using the Lumière screen specially prepared by them, then developing, reversing, intensifying, toning, fixing, and drying off the finished result.

While carrying out his investigations in connection with colour-photography, the author has found it an advantage to depart from the proportions, as adopted in the Lumière method of development, of the chemicals used in certain baths; he has also been able to overcome a weakness in these plates due to frilling.

ON A MAGNETIC CLUTCH.*

By W. E. Townsend.

Some six or seven years ago, when Mr H. W. Ravenshaw was making a small power automobile of comparatively large weight—the car weighed 33 cwt., and the engines were 5¼ B.H.P.—it was found necessary to make a clutch which could be slipped indefinitely while transmitting the full power of the engines. It was known that no mechanical clutch would perform this. Mr Ravenshaw then turned his attention to designing an electro-magnetic clutch.

For years previously many inventions had been patented in connection with electro-magnetic clutches, but none of these inventions have been found quite satisfactory, principally owing to the residual magnetism left in the metal of the magnet after the current has been interrupted. Over one hundred and forty patents have been taken out to overcome this difficulty: *e.g.*, reversing the direction of the electric current, inserting non-magnetic plates between the poles of the magnet and its keeper, etc. In the former case, unless the current were again interrupted at the exact moment when the original magnetism had been overcome, the metal became magnetised again, and so prevented a release of the keeper. In the latter case the non-magnetic face wore away so quickly that the effective power of the magnet varied, and the trouble and expense of renewing these faces was very considerable. After many experiments, Mr Ravenshaw discovered what is claimed to be the first reliable method of overcoming the residual magnetism in electro-magnets. It is almost inconceivable why this had not been done before, but perhaps the reason given by Mr Ravenshaw to the author is the correct one. Mr Ravenshaw is of opinion that the experimentalists had not sufficient technical knowledge to enable them to work out the necessary alteration to the magnet to arrive at the proper solution of the difficulty. The invention of Mr Ravenshaw is simplicity itself, and can be briefly described as "instead of having two breaks in the magnetic circuit, having at least three." This additional break in the magnetic circuit is exceedingly small, and has been found, after many experiments, to be most suitable at between 0.003 and 0.008 of an inch.

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* Read and illustrated before the Society on 23rd March 1908.

The author claims to be the "discoverer" of Mr Ravenshaw's invention, but, with the exception of carrying out a large number of experiments, making small alterations (chiefly mechanical), and testing clutches in actual working, he has done nothing.

The author decided to try a magnetic clutch on a more modern and powerful car, and had one fitted to a 20/25 H.P. car. This clutch takes the place of the flywheel and the male and female parts of the old clutch on the 20/25 H.P. car, and is of the same diameter and the same kinetic energy. A sectional view of the above-mentioned clutch is shown in Fig. 1.

An electric collector ring A of brass is insulated from the magnet outer ring B of steel casting which forms one of the poles, and is magnetically insulated by three thicknesses of thin tracing cloth from the magnetic core C, also a steel casting, forming the other pole. The wire for carrying the electric current is wound on a brass "former" D. This winding is exceedingly simple, and consists of a single No. 18 S.W.G. copper wire, double cotton covered. The first few turns are bared of insulation and soldered on to the brass former, the other end of the winding is taken through an insulating bush and fastened to the collector ring A.

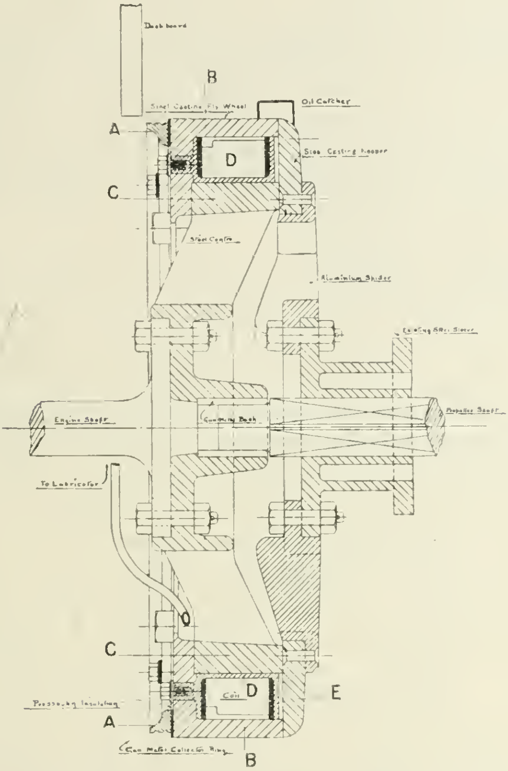

FIG. 1.

The keeper or driven disc E consists of a steel casting with a non-magnetic spider.

With the exception of the fastening bolts, the illustration shows the whole of the clutch.

A clutch similar to the above was used on a car for 28,000 miles without any alteration except twice renewing the "brush" wire to the collector ring, occasionally lubricating the contact faces, and recharging the battery.

The "brush" wires cost about one halfpenny each, and as the current required is only 1 ampere at 4 volts, it can easily be understood that the cost of recharging the battery was small. This clutch was used with dry surfaces and without any lubrication for 1,200 miles. The clutch was used during the 28,000 miles running largely for proving its slipping capabilities, much more than would have been done in actual use. During this long test the wear on the surfaces of the clutch was not more than $\frac{1}{64}$ of an inch. This small amount of wear is due to the case-hardening of the surfaces, the use of which is also patented.

Altogether five separate patents have been taken out in connection with this magnetic clutch, the principal patent being that of the third gap which the author here calls "Patent A." Along with this patent is what is known as the *Intermittent Grip*, which is a simple method of automatically making and breaking the current so as to give the desired "slip" to the clutch (Fig. 2).

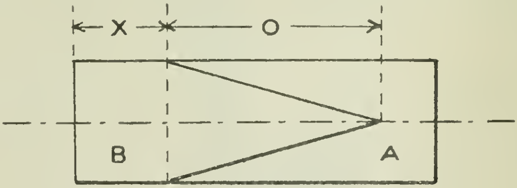

Fig. 2

A is an insulated cylinder revolving with any part of the engine, *e.g.* the half-time shaft, and having fitted upon it a brass sleeve B, which completely surrounds A through the distance X, but is cut away to nothing through the distance O.

The current is taken direct from the battery to a brush in permanent contact with B. Another movable brush, free to slide through the distance O and making contact with B, carries the current from B to the brush wire on the collector ring of the electro-magnet. When the movable brush is next to X the current is not interrupted, and no slip can take place between the clutch and keeper, as the parts are in full magnetisation. When the movable brush is moved along the distance O, the current is interrupted more or less according to the distance this brush is moved away from X, thus interrupting the current and so magnetising or not, according to the proportions of make and break.

This "A" type clutch has been thoroughly tested by Professors Stanfield and Barr, to whom the writer is deeply indebted for some very valuable suggestions. Professor Stanfield pointed out the adaptation of the clutch to many other uses than that of automobiles, such as large rolling mills, etc. Professor Barr has made a large number of tests, and has obtained most satisfactory results.

According to Professor Barr's experiments, at 4 volts the clutch transmitted nearly 80 B.H.P., which allows a useful factor of safety for a 4-cylinder internal combustion engine. By increasing the voltage—the current also being increased proportionally up to 6.5 volts—the power transmitted was 95.5 B.H.P., and at this point the magnet is almost fully saturated. The friction between the magnet and keeper at this point was estimated to be too great for the metals, and subsequent tests have verified this.

After the clutch had been thoroughly tested, as already mentioned, it was decided to try magnetic clutches in place of mechanical ones in an automatic regulator, for operating the nozzle spear in a "Cassel" water-wheel. This water-wheel maintains a uniform speed at all loads, but does not in any way control the quantity of water, either at full or light load. A simple form of gear-box was designed, employing one speed forward and one speed reverse. The action of the wheel, when running on light loads, operates a switch in connection with one of the magnetic clutches, which then attracts its keeper, to which is fastened a spur-wheel engaging with another spur-wheel, which operates the "screw" shaft, and so moves the spear into the nozzle of the water-wheel, thus shutting off water until the action of the wheel breaks the electric switch and frees the spur-wheel from the clutch, when the spear remains at rest.

When running under loads the opposite action takes place—the water-wheel operates another switch, which is in connection with the second clutch operating its set of wheels, including an idle pinion for obtaining a reverse motion. One of these regulators has been in constant use for two years at Murthly Castle. So sensitive is the action that the addition or reduction of 2-16 candle-power incandescent electric lamps operates the clutch and increases or decreases the flow of water, as the case may be. From the successful working of this arrangement has followed the design of a gear-box for operating machine tools, rolling mills, etc.

In many cases it was found undesirable to use this "A" type of clutch, principally owing to the diameter being determined by the power to be transmitted at low speeds. This difficulty was overcome by the "B" type of clutch, which is the second type patented, and which has many advantages over the "A" type; but the "B" type, and, in fact, all the types, are based on the extra gap of the "A" type patent.

Description of "B" Type.—The chief feature of this type is in having an intermediate element consisting of two concentric rings of magnetic material connected by a ring of flexible non-magnetic material, and adapted to close upon the electro-magnet.

The sectional drawing of the clutch (Fig. 3), designed for a 50 H.P. 6-cylinder automobile, clearly shows the various parts.

A. Brass collector ring.
B. Magnet ring or one pole of magnet. (A steel casting.)
C. Magnet core or other pole of magnet. (A steel casting.)

D. The former on which the coil is wound.

E. The keeper. (A steel casting.)

All these are similar to the "A" type clutch.

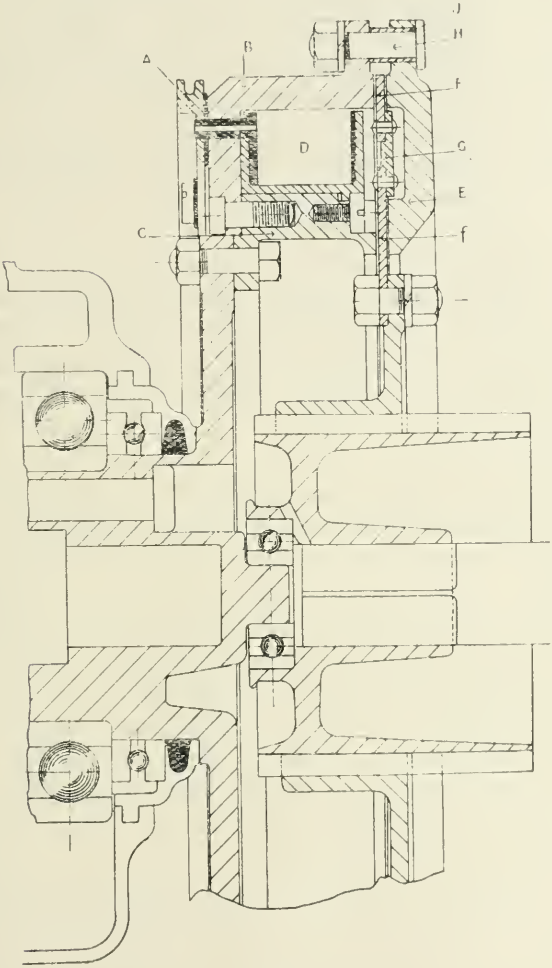

FIG. 3.

The extra gap is between "B" and "C," and not shown, as the space is only 0.007 of an inch, and cannot be drawn.

F and f. The two concentric magnetic rings joined together by the flexible non-magnetic ring G. F, f, and G form the intermediate element which is fixed to the driven shaft and free to move between the magnet and keeper. The two latter are joined together by bolts H, which have a sliding fit on the bushes J. The magnet is, in this case, fastened to the engine shaft, or rather to the face of the engine flywheel, from which the rim has been cut.

It can therefore easily be understood that the inertia of the intermediate element being very slight, it will come to rest quickly when the current is interrupted or broken. This intermediate element only weighs $3\frac{1}{4}$ lbs., and has a kinetic energy of only 130 foot-lbs. at 1,000 r.p.m.

The clutch which has been replaced by this magnetic clutch on this particular automobile was a very well-known multiple disc clutch, having a kinetic energy of over 500 foot-lbs. at 1,000 r.p.m. The clutch here described takes 1.3 amperes at 4 volts, and slips at 130 H.P. at 1,000 r.p.m. To reduce the cost of manufacture of the intermediate element a solid disc of steel with 28 holes, each of $1\frac{1}{8}$ inch diameter, has been used, thus saving the somewhat costly brass ring G, and the cost of fastening it by riveting to F and f. The result is in every way highly satisfactory. The slight magnetic leak from F to f through the metal between the holes is almost negligible.

By increasing the number of the intermediate elements in the same size of clutch, the power transmitted is greatly increased. A clutch of the same diameter as the one referred to above, and having two intermediate elements, increases the power of the clutch from 130 to 260 H.P. By adding three intermediate elements the power is increased to 390 H.P.

It is this type of clutch which has been in use in a change-speed gear-box of a 20/25 H.P. automobile for eighteen months, during which time the car has travelled not less than 9,000 miles. Owing to the small distance between the shafts of the gear-box, only small diameter clutches could be used. It was necessary to fix the clutches to the lay shaft of the gear-box. This shaft runs always much slower than the engine shaft and the first time shaft of the gear-box, owing to the design of the gear-box and wheels. It was necessary, therefore, to have a large number of intermediate elements, especially in the "first speed" when the power to be transmitted is the greatest and the speed of lay shaft the slowest. This gear-box has worked perfectly, and allows of the gears being changed as often as is desired without any noise whatsoever, and without the barbarous method universally employed in automobiles, of sliding (!) moving toothed wheels into toothed wheels moving at a faster or slower speed.

A "B" type clutch, 36 inches in diameter and having three intermediate elements, will transmit 3,000 H.P. at 1,000 r.p.m. All faces in this type, as well as in the "A," "C," and "D" types, are case-hardened.

The success of the "B" type clutch led to the designing of the "C" type, which is in many ways similar to the "B" type, but, owing to certain details, it can be made in a very compact form, and is probably the smallest magnetic clutch that it is possible to make to transmit a given power. The coil is well protected, and the wire can be directly wound on to the magnet without the intervention of a metal reel or former.

This type is particularly applicable to gear-boxes where space is limited. The keeper is formed of two concentric parts, one surrounding the other, which helps the quick disengagement of the clutch and allows for any inequality in the contact faces.

Type "D" Clutch.—This type differs from the "C" type mainly in placing the intermediate elements concentric with and within the energising coil. By this means greater simplicity and economy of construction are obtained. The intermediate elements may be made very light, and so give a minimum of inertia. This is a compact form of clutch suitable for large sizes.

It follows from the above descriptions of the " A," " B," " C " and " D " type clutches that any of them may be used as brakes which can be used lightly or not as required, and with a smooth and even working.

REPORT BY COMMITTEE.

The undersigned Members of your Committee have studied Mr Townsend's description of the Ravenshaw Magnetic Clutch, together with the reports of Professors Barr and Stanfield, and they have examined the A and B forms of clutch in Mr Townsend's workshops, making tests on the B pattern clutch. The particular example tested slipped at a torque, which represented the transmission of 70 H.P. at a speed of 1,000 r.p.m. The special points noted were:—

1. The clutch releases instantaneously when the current ceases.

2. The attractive force between the plates increases gradually, reaching its full value after two or three seconds. On account of this, the clutch slips at the moment when the strain of starting commences, and the shock of a sudden start is diminished.

3. The rate of rise of the attractive force, and the value at its maximum, are very constant.

4. The electric power absorbed by the clutch is very small. In the test cited above, the current was only 0.7 amperes at 4 volts pressure, or a total expenditure of less than 3 watts, while at the speed given above the clutch would transmit over 50,000 watts.

5. The use of an intermittent current affords an easily controllable means of varying the driving power of the clutch, which appears remarkably successful from Professor Barr's tests.

6. The application of magnetic attraction to the multiple disc pattern of clutch has successfully combined the compactness and power of the multiple disc with the ease of control and reliability of the magnetic clutch. The live parts possess little rotational inertia, and there are no sliding surfaces when the clutch is in action, except the very small surface of the electric contact.

The Members of your Committee have no criticism to offer, and they commend the Paper to the consideration of the Prize Committee. They understand that Mr Townsend is not the inventor of the fundamental idea of the clutch—viz., an air-gap in the yoke-piece or back of the magnetic circuit—but they believe that he has done much ingenious work in the smaller improvements, and in the adaptation of the clutch to useful purposes.

FRANCIS G. BAILY, *Convener.*
ALEXANDER OGILVIE.
DAWSON TURNER.

APPENDIX (A).

PROCEEDINGS OF THE ROYAL SCOTTISH SOCIETY OF ARTS, SESSION 1907-1908 (BEING THE 87TH SESSION).

First Meeting.—THE ANNUAL GENERAL MEETING of the Royal Scottish Society of Arts was held in the Hall, 117 George Street, on Monday evening, the 11th of November 1907, at 8 o'clock. Professor T. Hudson Beare, President of the Society, occupied the Chair, and was supported by Lord Kingsburgh and Mr Ritchie, Vice-President.

The President, after referring to the losses by death which the Society had sustained during the preceding Session, and to the Papers which had been read, passed on to the main subject of his Opening Address, which was entitled "Some Notable Events in the Engineering World during the Session 1906-1907." The cantilever type bridge to cross the St Lawrence close to Quebec was first dealt with. Referring to the disaster of 29th August last, when the entire completed superstructure on the south side collapsed, Professor Beare was of opinion that the ultimate cause would be found to be faulty design, and not bad workmanship or bad material. The design and construction of the various members was considered in detail and in working out the stresses in one of the compression members. It would appear that much higher working stress had been adopted in the Quebec Bridge than in the Forth Bridge. Professor Beare afterwards gave some very interesting facts concerning the two new Cunard turbine-driven liners—the *Lusitania* and the *Mauritania*. The design and construction of the propelling machinery and boilers was very fully described; also details were given of the trials of the two ships.

At the conclusion Mr Ritchie moved a hearty vote of thanks to Professor Beare for his very interesting and valuable address. Mr Graham-Yooll seconded the motion, which was agreed to.

The Secretary then read the report of the Prize Committee, and the President presented the prizes to the several recipients.

Private Business.

1. The Minute of the meeting of 8th April was read and approved.

2. The Society elected the following Office-bearers for the coming Session, the same having been recommended by the Council:

President . . .	T. Hudson Beare, B.Sc., M.Inst.C.E. & M.E., F.R.S.E.
Vice-Presidents . .	William Allan Carter, M.Inst.C.E., F.R.S.E. A. P. Laurie, D.Sc., F.R.S.E.
Secretary and Editor of Transactions	Richard Stanfield, M.Inst.C.E., F.R.S.E.
Treasurer . . .	C. J. Shiells, C.A.
Librarian . . .	Ellice M. Horsburgh, M.A., B.Sc., F.R.S.E.
Medallists . . .	Alexander Kirkwood & Son.
Officer . . .	Francis Duffy.

Councillors.

Hippolyte J. Blanc, R.S.A., F.R.I.B.A.
Henry M. Cadell, B.Sc., F.R.S.E.
Jas. D. Gibson.
Stevenson Macadam, F.I.C., F.C.S.
John F. Barton.
John Cran.
A. F. Clement.
John White.
R. C. Brebner, Assoc.M.Inst.C.E.
James Massie, M.Inst.C.E.
A. Louis Reis, F.S.M.C.
W. Graham-Yooll.

The Society then adjourned.

Second Meeting — 25th November 1907 — 8 *o'clock.* — In the absence of the President, who was unavoidably prevented from being present, Mr W. Allan Carter, Vice-President, occupied the Chair.

Sir James A. Russell, LL.D., exhibited and described Gibb's Helio-Chronometer, a development of, and a great improvement on, the older form of sundial. By Mr Gibb's invention standard mean solar time can be obtained by direct observation, no corrections or allowances being required. The chronometer can be easily adjusted for latitude and longitude; its accuracy is unimpaired by transference from place to place; atmospheric refraction can be neglected, and it is easily set up in true position. By means of the helio-chronometer on exhibition and by lantern diagrams Sir James Russell explained fully the parts of the instrument and its method of adjustment for any season, latitude, or longitude. Dr Hunter also spoke, and on the motion of the Chairman Sir James Russell was cordially thanked for his communication.

Mr James Gray then exhibited and explained a new cabinet for the storing of drawing paper, tracing paper, etc., for which Mr Gray claimed saving in time and trouble, and also economy, waste being reduced to a minimum. Mr Gray very fully described his invention, and showed its working. Mr Clark, who spoke subsequently, commended the cabinet as being likely to prove of use in drawing offices. A committee, consisting of Messrs Cran, Clark, and J. Smith, with Mr Cran as Convener, was appointed to consider Mr Gray's invention and report. Mr Gray was unanimously thanked for his communication.

Private Business.

1. The Minutes of last meeting were read, approved, and signed.

2. The following gentlemen were proposed and unanimously elected Ordinary Fellows of the Society:—David Greig; Dr Emil Westergaard; William Robertson, M.D., D.P.H.; G. H. Gulliver, B.Sc.; and John Menzies.

The Society then adjourned.

Third Meeting—9th December 1907.—Professor T. Hudson Beare, President of the Society, occupied the Chair. Mr Alexander Clark, Assoc.M.Inst.C.E., read a communication on "Sewage Deodorisation—Treatment at Source."

In his communication Mr Clark submitted to the Society an invention of his own for the deodorisation and disinfection of sewage. After referring to the known dangers of noxious sewage gases in dwelling-houses, etc., he described very fully his invention, which consists of a chamber attached to the usual flushing cistern of a w.c., and containing a deodorising and disinfecting agent (permanganate of potash or soda), a certain proportion of which is carried into the pan along with the flushing water. Mr Clark advocated compulsory adoption of such a system, claiming for it economy and simplicity and effectiveness, and comparing it with the various other systems for the treatment of sewage by Precipitation, Sewage

Farm System, and the Septic Treatment. Mr Clark had on exhibition a w.c. with flush cistern and chamber containing the disinfectant attached. The chamber is about one-tenth the capacity of the flush cistern, the cost of fitting the chamber varying from 10s. to £1, according as the cistern is new or old. The cost of the material is about 1d. a week. The effluent is comparatively clear and pure.

An interesting discussion followed, taken part in by Messrs Hislop, Proctor, Pilkington, Hume, Smith, the President, and others; and after Mr Clark had replied, the Chairman conveyed to him the thanks of the Society for his most interesting communication; and it was remitted to a committee, consisting of Messrs J. B. Bennett, G. H. Gemmell, William Allan Carter, the last-named as Convener, to consider Mr Clark's communication and report.

Private Business.

The Minutes of last meeting were read, approved, and signed.

The Society then adjourned.

Fourth Meeting—13th January 1908.—Professor T. Hudson Beare, President of the Society, occupied the Chair, and was supported by Lord Kingsburgh.

Mr Edward L. Brown read a Paper on "Direct Colour-Photography by the Lumière Process."

After giving a short account of previous attempts to depict objects in their natural colours, Mr Brown explained how the plates as used in the Lumière process are made, and how they are affected by colour so as to produce a negative in the complementary colour of the object being photographed. It appears that the principal body of these plates consists of very fine starch grains dyed in the three primary colours, the plates being coated with a certain proportion of each colour; the general effect on the eye being that a certain colour or shade is produced according to the proportion made visible. The method of obtaining the positive in the true colour of the object was fully described. In the development of the plates no less than nine different baths are used; and in this important part of the process Mr Brown appears to have introduced certain important modifications which have contributed to success. To illustrate his Paper, Mr Brown had on view in the adjoining room about forty beautiful examples of Colour-Photography, which he had taken, comprising portraits, fruit, flowers. interiors, etc., in their natural colours.

A very interesting discussion followed, in which Messrs Cadell, Day, Horsburgh, Boa, Professor Baily, and the President took part.

The President conveyed to Mr Brown the thanks of the Society for his very interesting Paper.

Private Business.

1. The Minutes of the last meeting were read and approved.

2. The following gentlemen were balloted for and duly elected Ordinary Fellows of the Society:—Edward L. Brown; John L. Adam; J. Duncan Cran; William J. Denholm; George Proven; Thomas C. Steven; Charles B. Boog Watson.

The Society then adjourned.

Fifth Meeting—27th January 1908.—Dr A. P. Laurie, Vice-President, occupied the Chair in the absence of the President, who was unavoidably prevented from being present.

Mr G. H. Gulliver, B.Sc., F.R.S.E., made a communication on the "Microscopical Structure of Metallic Alloys."

Mr Gulliver first of all explained how the metals were prepared for microscopical examination, and then described the structure of a pure metal. He next dealt at considerable length with the process of crystallisation, and with the corresponding appearance of the metal after solidification. Mr Gulliver then discussed the structures produced by mixing metals in various proportions, and considered both simple alloys as well as the more complicated alloys, such as the copper-tin series and the iron-carbon series. The communication was illustrated with a large number of excellent lantern slides, showing the structure of the alloys very clearly.

In the subsequent discussion Professor Baily, Mr Frazer, Mr Clark, and others took part, and some interesting questions were asked; and, after Mr Gulliver had replied, the Chairman conveyed to him the thanks of the meeting for his communication.

Private Business.

1. The Minutes of last meeting were read, approved, and signed.

2. The following gentlemen were proposed and unanimously elected Ordinary Fellows of the Society:—George Romanes, B.Sc.; John Gibson, Ph.D., F.R.S.E.; James Gray, M.I.Mech.E.

The Society then adjourned.

Sixth, Seventh, Eighth, Ninth, and Tenth Meetings—10*th*, 17*th*, *and* 24*th February, and 2nd and* 9*th March* 1908.—Professor T. Hudson Beare, President of the Society, presided on the evenings of the 10th and 17th February and the 9th March, and Mr William Allan Carter, Vice-President, occupied the Chair on 24th February and 2nd March.

These evenings were devoted to the Keith Lectures on Brewing, which were delivered by Dr Emil Westergaard, Lecturer on Technical Mycology in the Heriot-Watt College.

The lectures dealt in a most comprehensive manner with the whole subject of Brewing, from the growth of the barley and the hops to the despatch of the beer to the consumer. The lecturer dealt in detail with the barley, the hops, the water, the grinding, the mashing, and the boiling processes, the bottling and the storage. The first lecture was almost entirely devoted to a discussion of the various views held as to the nature of the fermentation processes and the relations of the enzymes to the fermentation. The various yeasts, their functions and behaviour, were fully described, as were the methods employed during the various processes. The lecturer discussed many of the difficulties met with in practice, and the methods adopted to overcome them, and referred to the latest scientific investigations bearing on this most important industry. All kinds of beers were dealt with, from the—generally speaking—light Continental beers to the heavier British beers. The lectures were illustrated by a large number of lantern slides, and by samples.

At the conclusion of the last lecture of the series, which had been closely followed by the members of the Society, and by others who were interested in the subject, the President conveyed to Dr Westergaard a hearty and unanimous vote of thanks.

Private Business.

On the evening of 2nd March the following were proposed and unanimously elected Ordinary Fellows of the Society:—Sheikh Abulfazl; James Tudor Cundall, B.Sc.; James Y. V. Johnson: George A. Gibson, M.D., D.Sc.: William Shearer.

Eleventh Meeting—23*rd March* 1908.—Professor T. Hudson Beare, President of the Society, occupied the Chair.

The Right Hon. Sir J. H. A. Macdonald (Lord Kingsburgh) read a communication to a large audience on "Recent Developments in Power Traction on Roads."

His Lordship gave an interesting *resumé* of the development of motor traction, and gave interesting statistics as to the number of motor-propelled vehicles and to capital invested. He considered motor vehicles from the point of view of public and commercial utility, pointing out that they were more economical than horsed vehicles, and capable of covering a far wider range of ground. His Lordship dealt with internal combustion engines in all their aspects, sparking plugs, carburettors, communication of power to wheels, the clutch, change-speed gear, speed control, and the problems associated with the wheels, elimination of road shocks, and side-slip. Special reference was made to the Renard Road Train, and his Lordship showed a large number of interesting lantern slides. At the conclusion of Lord Kingsburgh's communication, Mr W. E. Townsend exhibited and explained his Patent Magnetic Clutch and Change-Speed Gear.

Mr Robert J. Smith, Bailie Mackenzie, Professor Baily, and the Chairman having spoken, the Chairman conveyed to Lord Kingsburgh and to Mr Townsend the unanimous and hearty thanks of the Society for their communications, and it was remitted to the following committee to consider Mr Townsend's communication and report:—Dr Dawson Turner, Mr Alexander Ogilvie, and Professor Baily (the last-named as Convener).

Private Business.

The Minutes of the last meeting were read, approved, and signed.

The Society then adjourned.

Twelfth Meeting—13*th April* 1908.—Mr Wm. Allan Carter, Vice-President, occupied the Chair.

Dr Drinkwater read a communication by himself and Mr Henry O'Connor on "Arsenic-Free Gas-Coke."

The authors first described the arsenic scare of 1900, and the report of the Manchester Commission condemning, among other things, gas-coke for malting purposes, and then proceeded to detail the experiments made by them to reduce the small amount of arsenic in gas-coke. The process, as patented by them, consists in the sprinkling of a small quantity of common salt upon the coal before it is put into the retort, so that as the chlorine is evaporated by the heat, it carries with it the arsenic, leaving only a minute quantity in the coke. Reports of experts were presented showing the very small quantities of arsenic (volatile and fixed) left after the treatment.

A description of some suggested tests for arsenic in fuels completed the Paper.

In the subsequent discussion Mr Carter and Mr Clark took part.

After Dr Drinkwater had replied to the several questions raised, the Chairman conveyed to the authors of the communication the hearty thanks of the Society.

The communication was remitted to the following committee for report, viz.:—Messrs Herring, Gemmell, and Westergaard, the first-named being Convener.

A communication was submitted by Dr James R. Milne on "Improvements in Means for Preventing or Counteracting Backlash in Gearing."

The device adopted is virtually equivalent to a form of wheel with elastically expanding teeth. One of the two wheels that gear together is split in half, so as to make two wheels similar to the original one, but half as thick. One of the halves is fixed rigidly to the axle, while the other turns loose upon it. The two halves are connected together by means of a spring which forces them in opposite directions. The result is that the corresponding teeth on these halves turn past each other until they completely fill up the spaces between the teeth of the wheel with which they gear, thus preventing backlash.

Messrs O'Connor, Pilkington, Anderson, Horsburgh, and the Chairman having spoken, Dr Milne replied.

The hearty thanks of the Society was conveyed to Dr Milne for his interesting communication, which was remitted to the following committee:—Messrs Gray, A. Wilson, and J. Cran—the latter being Convener.

Private Business.

1. The Minutes of the last meeting were read, approved, and signed.

2. The following gentlemen were proposed, balloted for, and unanimously elected Ordinary Fellows of the Society:—James Robert Milne, D.Sc., F.R.S.E.; John Richard Milne.

The Society then adjourned.

Thirteenth Meeting—22nd June 1908.—Dr A. P. Laurie, Vice-President, occupied the Chair.

The following Reports by Committees were submitted and approved:—

On Mr James Gray's Paper (4906). Mr Cran, *Convener.*
On Mr Townsend's do. (4912). Professor Baily, *Convener.*

On Mr O'Connor and Dr Drinkwater's Paper (4913). Mr Herring, *Convener.*

On Dr J. R. Milne's Paper (4914). Mr Cran, *Convener.*

The Report on Mr Clark's Paper (4907), when received, to be submitted to the Prize Committee for consideration.

Private Business.

The Minute of the last meeting was read, approved, and signed.

The Society appointed the following gentlemen to act as Prize Committee for the current Session :—

Professor T. Hudson Beare, President ; Mr Wm. Allan Carter ; Dr A. P. Laurie ; Mr John Cran ; Professor Baily ; Messrs W. R. Herring ; Thomas Proctor ; Dr Westergaard ; Archibald Wilson and P. Boa, Treasurer and Secretary.

Professor Baily called attention to an alleged violation of one of the laws of the Society by the Council in omitting to have a motion, which had been previously sent to the Secretary, printed in the billet for discussion at the present meeting. The Secretary explained that the motion had been brought before the Council, and that he had been instructed by the Council to communicate with Professor Baily, and point out to him that the matter to which he referred was receiving serious consideration, but it was suggested that it might be left over for a more convenient time. The general opinion of the meeting was that the Council had overlooked the law referred to, and on that account might be considered to blame, but it was felt that the Council did not wish to act in any way discourteously towards Professor Baily.

The Society then adjourned.

APPENDIX (B).

REPORT OF THE COMMITTEE APPOINTED BY THE ROYAL SCOTTISH SOCIETY OF ARTS TO AWARD PRIZES FOR COMMUNICATIONS READ OR REPORTED ON DURING THE SESSION 1907-1908.

Your Committee having met and carefully considered the Communications laid before and definitely disposed of by the Society during the Session 1907-1908, begs to report that it has awarded the following Prizes:—

To James Gray,—for his Paper on "A Drawing Office Cabinet for the Supply of Paper, etc., from Rolls" (No. 4906),—read on the 25th of November 1907,

A Hepburn Prize, value Three Sovereigns.

To James R. Milne,—for his Paper on "Improvements in Means for preventing or counteracting Backlash in Gearing" (No. 4914),—read on the 13th of April 1908,

A Keith Prize, value Three Sovereigns.

To Henry O'Connor and Thos. W. Drinkwater,—for their Paper on "Arsenic-free Gas-Coke" (No. 4913),—read on the 13th of April 1908,

Keith Silver Medals.

To W. E. Townsend,—for his Paper on "A Magnetic Clutch" (No. 4912),—read on the 23rd of March 1908,

A Makdougall-Brisbane Silver Medal.

To G. H. GULLIVER,—for his Paper on "The Microscopic Structure of Metallic Alloys" (No. 4909),—read on the 27th of January 1908,

The Society's Complimentary Silver Medal.

To E. LUMSDEN BROWN,—for his Paper on "Colour-Photography" (No. 4908),—read on the 13th of January 1908.

The Society's Complimentary Silver Medal.

That the hearty thanks of the Society are due to the President, Professor T. HUDSON BEARE, for his Opening Address delivered on the 11th of November 1907, and to the Right Hon. Sir J. H. A. MACDONALD and to Sir JAMES A. RUSSELL for their Communications.

All of which is reported in name and by order of
the Prize Committee by

RICHARD STANFIELD, *Secretary,*
Convener, ex-officio.

SOCIETY'S HALL, 117 GEORGE STREET,
EDINBURGH, 21*st October* 1908.

APPENDIX (C).

LIST of PRIZES OFFERED by the ROYAL SCOTTISH SOCIETY of ARTS for PAPERS WHICH MAY BE SUBMITTED DURING THE SESSION 1908–1909.

(1) A KEITH PRIZE, value Thirty Sovereigns.

For some important "Invention, Improvement, or Discovery in the Useful Arts which shall be primarily submitted to the Society" during the Session.

(2) A HEPBURN PRIZE, value Twelve Sovereigns.

For such Invention or Communication submitted to the Society as shall be approved of by the Society, or by their Prize Committee.

(3) A MAKDOUGALL-BRISBANE PRIZE, value Ten Sovereigns.

To the Authors of Communications of Merit, or for Inventions which shall be approved of by the Society, or its Committee, and judged by them deserving of such distinction.

(4) REID and AULD PRIZES, value about Seven Sovereigns.

For the First, Second, and Third best Models of anything new in the Art of Clock or Watch Making—by Journeymen or Master Watch and Clock Makers—if these should be considered worthy of prizes. The sum mentioned above to be divided in such proportions as the Prize Committee shall fix. The Society, if it sees fit, may add to the amount available for these Prizes out of its general funds.

The Society may offer a Special Keith Prize to be competed for during the Session, details of which will be submitted to the Society at a later date.

The Society proposes to award the above Prizes for approved Communications submitted to the Society by Fellows or others, relative to Inventions, Discoveries, and Improvements in the Industrial Arts, or to means by which the Natural Productions of the Country may be made more available, whether the subjects treated have been patented or not. The Society suggests the following as a few of the many subjects suitable for such Communications:—

1. *Mechanical Arts.*

Inventions of, or Improvements relating to, Wind and Water Prime Motors; Steam and other Heat Engines; Pumping, Blowing, Rolling, Sawing, Agricultural and other Engines and Machines; Machinery used in the manufacture of Cotton or other Textile Fabrics; Shipbuilding, including Machinery, Appliances, and Materials used in same; Marine Propellers; Lighthouses and Lighthouse Appliances; Railways, including Structural Work, Plant, and Signals; Electrical Machinery and Apparatus; Mechanical Photographic Processes; Fireproof Buildings; Water Works; Sewage Works; Methods and Appliances for improving the Sanitary Conditions of Towns; Appliances for the Prevention of Smoke and Extinction of Fires; Gas Works and Gas Lighting; Canals, Inland Navigation, and Machinery employed for Canal Traffic, including Locks, Inclines, and Lifts; Hydraulic Machinery as applied to Lifts, Cranes, Printing Presses, Organ Blowers, and other purposes; Tools, Implements, and Appliances used in the various Trades; Bricks, Tiles, Cements, and Mortars; Printing Machines and Appliances connected therewith; Stereotyping and other similar Processes; Processes for the Preservation of Timber and Metals; Optical and other Scientific Apparatus; etc., etc., etc.

2. *Chemical Arts.*

Inventions or Improvements relating to Processes for the Treatment of Natural Productions; the Manufacture of Chemical Substances used in Commerce, Science, or Art; the Application of Chemistry to particular Manufactures and Trades; etc., etc., etc.

3. *Fine Arts.*

Inventions or Improvements relating to all kinds of Photographic Processes as applied to the Production of Illustrations; Engraving Processes; Lithography; Die-Sinking; Methods of applying Colours for Decorative Purposes; the Use and Treatment of various Materials for Wall Decoration; etc., etc., etc.

GENERAL OBSERVATIONS.

Communications are also invited describing Processes and Important Works, although no claim may be made by the Author on the score of Invention or the introduction of Improvements.

The Society reserves the right to withhold any of the Prizes offered for competition if the Papers submitted do not possess sufficient merit, or to award Prizes of smaller amounts, or to split up the amounts into a larger number of Prizes, as the Prize Committee may see fit.

In preparing Papers, the descriptions of Inventions, etc., should be full and distinct, written legibly on one side only of Foolscap paper, and, when necessary, the Communications should be accompanied by Specimens, Drawings, or Models. The Drawings should be in bold lines about $\frac{1}{4}$ of an inch broad, and strongly coloured, so as to be easily seen at about the distance of 30 feet when hung up in the Hall. Letters or Figures of Reference should be at least $1\frac{1}{2}$ inches long. When necessary, smaller and more minutely detailed Drawings should accompany the larger ones, for the use of the Committee, having the same letters of reference.

The Society shall be at liberty to publish in their *Transactions* Copies or Abstracts of all Papers submitted to them.

All Models, Drawings, etc., accompanying Papers for which Prizes are given shall be held to be the property of the Society; but the value of Models, if retained, will be allowed for.

Communications, Models, etc., are to be addressed to the Secretary, 117 George Street, Edinburgh, Postage or Carriage Paid. Communications lodged after the 1st of March may not be read or reported on till the following Session.

By Order of the Society,

RICHARD STANFIELD,
Secretary.

APPENDIX (D).

Royal Scottish Society of Arts.

ABSTRACT OF THE ACCOUNTS OF THE SOCIETY FOR 1906–1907.

I. GENERAL FUND.

Charge.

Income—			
Arrears of Subscriptions at 15th November 1906		£8 8 0	
Subscriptions for Session 1906-1907		83 9 6	
		£91 17 6	
Balance at Credit of Building Fund		31 2 1	
Miscellaneous Receipts		5 17 5	
Total Income			£128 17 0
Balance against the Society at 15th November 1907			178 7 5
Sum of the Charge...			£307 4 5

Discharge.

Balance due to the Treasurer at 15th November 1906			£39 11 5	
Medal awarded			1 3 6	
Ordinary Expenditure—				
Printing and Advertising		£1 18 1		
Salaries and Expenses of Collection,	£76 13 0			
Less—Charged to Prize Funds	12 12 0			
		64 1 0		
Expenses connected with the Society's Printed Transactions		176 4 1		
Interest paid to Keith Fund on Loan		5 14 2		
Miscellaneous Payments		4 19 2		
Total Ordinary Expenditure. .			252 16 6	
Arrears of Subscriptions written off			1 1 0	
Subscriptions Outstanding at 15th November 1907			12 12 0	
Sum of the Discharge...				£307 4 5

II. KEITH BEQUEST.

Charge.

Sum on Deposit with the Commercial Bank at 15th November 1906		£126 1 8
Income—		
Dividends from Stocks, viz. :—		
Edinburgh and Leith Gas Annuity	£28 10 0	
Great North of Scotland Railway Company Debenture Stock	19 0 0	
Forth and Clyde Junction Railway Preference Stock	4 15 0	
North British Railway Company Consolidated Lien Stock...	11 8 0	
	£63 13 0	
Interest on Loan to General Fund	5 14 2	
Bank Interest received	3 19 7	
		73 6 9
Sum of the Charge...		£199 8 5

II. KEITH FUND.

Charge Amount Forward			£199 8 5

DISCHARGE.

Balance due to Treasurer at 15th November 1906		£0 17 6	
Expenditure—			
Keith Fund Lectures	£83 7 2		
Expenses of Management, credited General Fund	5 5 0		
Prize awarded	20 0 0		
		108 12 2	
		£109 9 8	
Expense of Petition to Court for New Powers		60 0 11	
		£169 10 7	
Balance in favour of the Fund at 15th November 1907		29 17 10	
Sum of the Discharge			199 8 5

III. REID AND AULD BEQUEST.

CHARGE.

Sum on Deposit with the Commercial Bank at 15th November 1906		£175 4 4
Income—		
Interest on Great North of Scotland Railway Company Debenture Stock	£17 2 0	
On Forth and Clyde Junction Railway Preference Stock	2 7 6	
On North British Railway Consolidated Lien Stock	3 16 0	
Bank Interest	5 10 7	
		28 16 1
Sum of the Charge		£204 0 5

DISCHARGE.

Expenditure—			
Donations to poor Clockmakers in terms of the Bequest		£12 0 0	
Expenses of Management, credited General Fund		3 3 0	
		£15 3 0	
Sum on Deposit with the Commercial Bank at 15th November 1907	£189 17 5		
Less—Balance due to Treasurer	1 0 0		
		188 17 5	
Sum of the Discharge			204 0 5

IV. BRISBANE BIENNIAL PRIZE FUND.

CHARGE.

Sum on Deposit with the Commercial Bank at 15th November 1906		£52 15 3
Income—		
Interest on Forth and Clyde Junction Railway Preference Stock	£7 2 6	
Bank Interest	1 12 10	
		8 15 4
Sum of the Charge		£61 10 7

DISCHARGE.

Expenditure—		
Prizes awarded	£8 0 0	
Expenses of Management, credited General Fund	2 2 0	
	£10 2 0	
Sum on Deposit with the Commercial Bank at 15th November 1907	51 8 7	
Sum of the Discharge		61 10 7

V. HEPBURN PRIZE FUND.

CHARGE.

Sum on Deposit with the Commercial Bank at 15th November 1906		£66 8 10
Income—		
Dividends on Caledonian Railway Company Stocks	£7 1 4	
Bank Interest	2 1 8	
		9 3 0
Sum of the Charge...		£75 11 10

DISCHARGE.

Expenditure—		
Prize awarded	£10 0 0	
Expenses of Management, credited General Fund	2 2 0	
Sum on Deposit with the Commercial Bank at 15th November 1907	63 9 10	
Sum of the Discharge		75 11 10

VI. BUILDING FUND.

CHARGE.

Rents drawn from Letting the Hall		£169 16 6

DISCHARGE.

Payments on Account of the Hall and Hallkeeper's House, viz., Taxes, Feu-duty, Insurance, Coals, Gas, Cleaning, etc., and Hallkeeper's Salary	£134 15 2	
Repairs and Alterations to the Hall	3 19 3	
		138 14 5
Balance transferred to the General Fund, page 1		£31 2 1

FUNDS OF THE SOCIETY.

As at 15*th November* 1907, *per Report of the Auditor.*

I. GENERAL FUND.

Price of Hall in George Street and Furnishings, and of the additional Premises purchased at Whitsunday 1863		£2,712 0 3
Arrears of Annual Contributions		12 12 0
		£2,724 12 3
Deduct Loan from Keith Fund	£180 0 0	
Balance due to Treasurer, per Account on page 1	178 7 5	
		358 7 5
Amount of General Fund...		£2,366 4 10

II. KEITH BEQUEST.

£30 Annuity of the Edinburgh and Leith Gas Commission..	£870 0 0	
£500 Great North of Scotland Railway Company Debenture Stock	612 10 0	
£100 Preference Stock No. 1 of the Forth and Clyde Junction Railway Company	137 0 0	
£300 4 per cent. Consolidated Lien Stock of the North British Railway Company	406 15 0	
Cash Balance	29 17 10	
Loan to General Fund	180 0 0	
		2,236 2 10
Carry forward,		£4,602 7 8

II. FUNDS OF THE SOCIETY—continued.

Brought forward,				£4,602	7	8

III. REID AND AULD BEQUEST.

£450 Great North of Scotland Railway Company Debenture Stock	£551	5	0			
£50 Preference Stock No. 1 of the Forth and Clyde Junction Railway Company	68	10	0			
£100 4 per cent. Consolidated Lien Stock of the North British Railway Company	135	11	10			
Sum on Deposit with the Commercial Bank, *less* Cash Balance...	188	17	5			
				944	4	3

IV. BRISBANE PRIZE FUND.

£150 Preference Stock No. 1 of the Forth and Clyde Junction Railway Company	£205	10	0			
Sum on Deposit with the Commercial Bank	51	8	7			
				256	18	7

V. HEPBURN PRIZE FUND.

£175 Caledonian Railway Company Consolidated 4 per cent. Stock, No. 2	£209	2	6			
£11 do. No. 1	13	6	0			
Sum on Deposit with the Commercial Bank	63	9	10			
				285	18	4
Total Property and Funds under Charge of the Society as at 15th November 1907				£6,089	8	10

C. J. SHIELLS, *Treasurer.*

EDINBURGH, 15*th April* 1908.—I have examined and audited the Accounts of the Treasurer to the Royal Scottish Society of Arts for the Session 1906-1907, of which the foregoing is an Abstract, and beg to report that I have found the same to be correctly stated and sufficiently vouched. I have also examined the securities for the Invested Funds of the Society, and have found them in order.

GEORGE H. CARPHIN, C.A., *Auditor.*

APPENDIX (E).

LIST

OF THE

OFFICE-BEARERS AND FELLOWS

OF THE

ROYAL SCOTTISH SOCIETY OF ARTS

HIS MAJESTY THE KING, PATRON

OFFICE-BEARERS FOR SESSION 1908-1909

As elected on 9th November 1908.

President	William Allan Carter, M. Inst. C.E., F.R.S.E., 51 Queen Street.
Vice-Presidents	A. P. Laurie, D.Sc., F.R.S.E., Heriot-Watt College. Walter R. Herring, M. Inst. C.E., Granton House, Granton.
Secretary and Editor of Transactions	Richard Stanfield, M. Inst. C.E., F.R.S.E., Heriot-Watt College.
Treasurer	C. J. Shiells, C.A., 141 George Street.
Librarian	*Vacant.*
Medallists	Alexander Kirkwood & Son, 9 St James Square.
Officer	Francis Duffy, 117 George Street.

Councillors.

John F. Barton, 11 Forrest Road.
John Cran, Albert Engine Works, Leith.
A. F. Clement, 59 Braid Road.
John White, 17 East Claremont St.
Robert C. Brebner, Assoc. M. Inst. C.E., 4A St Andrew Square.
James Massie, M. Inst. C.E., 20 Tantallon Place.
A. Louis Reis, F.S.M.C., The Laurels, Bright's Crescent.
W. Graham-Yooll, 45 Stirling Road, Trinity.
Geo. H. Gemmell, F.I.C., F.C.S., 4 St Catherine's Place.
Lachlan P. Mackenzie, 5 Polwarth Terrace.
Alex. Ogilvie, B.Sc., Leith Electric Works.
Andrew Wilson, Assoc. M. Inst., C.E., 51 Queen Street.

LIST OF THE ORDINARY FELLOWS AND ASSOCIATES

AS AT 10TH NOVEMBER 1908

*Those marked * are Life Fellows.*

NOTE.—Fellows may become "Life Fellows" at any time on paying £10, 10s., from which they are allowed a deduction of half the amount they may have paid previously in Annual Contributions.

1908 Abulfazl, Sheikh, M.A., LL.D., Kapurthala, Jullundhar, India
1908 Adam, John L., c/o Messrs John Cran & Co., Leith
1871 *Aitken, John, F.R.S.E., Ardenlea, Falkirk
1851 *Alexander, William, M.E.
1907 Alexander, William, 9 Abercorn Road
1906 Anderson, Robert H., 27 Inverleith Row
1896 *Archer, Robert S., Clifton House, 47 Clifton Road, Birkenhead

1896 Baily, Francis G., M.A., F.R.S.E., M.I.E.E., Professor of Applied Physics, Heriot-Watt College
1878 *Barton, John Fraser, plumber, 11 Forrest Road, *Councillor*
1901 Beare, T. Hudson, B.Sc., M. Inst. C.E., M. Inst. M.E., F.R.S.E., Professor of Engineering, Edinburgh University
1859 *Bell, Andrew Beatson, advocate, F.R.S.E., 17 Lansdowne Cres.
1902 Bennett, James B., Assoc. M. Inst. C.E., F.R.S.E., 42 Frederick Street
1879 *Black, William Galt, F.R.M.S., 2 George Square
1883 *Blaikie, Walter Biggar, F.R.S.E., printer, 11 Thistle Street
1879 *Blanc, Hippolyte Jean, R.S.A., F.R.I.B.A., 25 Rutland Square
1888 *Boa, Peter, pharmaceutical chemist, 58C Morningside Road
1892 Bonar, Horatius, W.S., 3 St Margaret's Road
1853 *Bow, Robert Henry, C.E., F.R.S.E., 7 South Gray Street
1890 Brebner, R. C., Assoc. M. Inst. C.E., 4A St Andrew Square, *Councillor*
1908 Brown, Ed. Lumsden, 6 So. Clerk Street
1864 *Brown, Geo. Bruce, architect. (No address)
1880 *Bruce, A. Fairlie, C.E. (No address)
1868 *Bruce, C., banker, 3 Melville Crescent
1850 *Bruce, George Cadell, C.E.
1893 Buchan, Mathew, electrician, 16 Rutland Square
1893 Buchanan, James, 3 Oswald Road
1879 *Buchanan, John, C.E., 12 Hill Street

1891 Cadell, Henry Moubray, B.Sc., F.R.S.E., of Grange, Bo'ness
1906 Cadell, Lewis I., W.S., Brae Lodge, Murrayfield
1879 *Carfrae, George Somervel, C.E., 1 Erskine Place
1880 *Carmichael, Neil, M.D., 23 Nithsdale Road, Pollokshields, Glasgow
1892 *Carphin, G. H., C.A., 3 Abinger Gardens, Murrayfield
1875 *Carter, William Allan, M. Inst. C.E., F.R.S.E., 51 Queen Street, *President*

1872 *Cattanach, Peter Lorimer, advocate, 14 London Street
1867 *Cay, William Dyce, M. Inst. C.E., F.R.S.E., 39 Victoria Street, Westminster, London, S.W.
1879 *Clark, Alexander, Assoc. M. Inst. C.E., 51 East Trinity Road, Leith
1878 *Clement, Adam Ferguson, telegraph engineer, Egmont, 59 Braid Road, *Councillor*
1901 Cockburn, Alexander W., civil engineer, 39 York Place
1889 Colam, William N., M. Inst. C.E., 27 Rutland Square
1876 *Cormack, D. Adair, marine engineer, 17 Abercorn Terrace, Portobello
1906 Cormack, C. R., marine engineer, 7 John's Place, Leith
1872 *Couper, Charles Tennant, advocate, 3 Charlotte Square
1888 *Cowan, John, 6 Salisbury Road
1883 *Crabbie, George, merchant, 8 Rothesay Terrace
1885 *Cran, John, mechanical engineer, Albert Engine Works, Leith, *Councillor*
1908 Cran, J. Duncan, Tower Street, Leith
1876 *Cranston, The Rt. Hon. Sir Robert, K.C.V.O., Dunard, Grange Loan
1908 Cundall, Jas. Tudor, B.Sc., F.I.C., 1 Dean Park Crescent
1879 *Cunningham, James H., Assoc. M. Inst. C.E., 2 Ravelston Place

1892 Davidson, John, Langley Park, Wick
1908 Denholm, William J., 12 Elm Place, Leith
1882 *Dickson, Lamont, C.E., 135 George Street
1906 Drinkwater, Thos. W., Dr., F.R.S.E., Surgeons' Hall
1887 *Drysdale, Alexander, builder, 70 Pilrig Street
1893 *Duncan, D. J. Russell. (No address)

1907 Eadie, Andrew, 22 Melville Terrace
1892 Elgin and Kincardine, The Right Hon. The Earl of, K.G., Broomhall, Dunfermline

1878 *Farquharson, Thomas Ker, accountant, 100 Thirlstane Road
1857 *Ferguson, R. M., LL.D., Ph.D., F.R.S.E., 5 Douglas Gardens
1895 *Ferranti, S. Z. de, engineer, Grindleford, Sheffield
1904 Finlay, William, electrical engineer, 16 North St Andrew Street
1894 *Foulis, David, jun., 42 Shandwick Place
1850 *Fraser, Alexander, printer, 17 Eildon Street
1879 *Frazer, Alexander, M.A., optician, 22 Teviot Place

1896 *Geddes, C. D., mining engineer, 21 Young Street
1899 Gemmell, George H., F.I.C., F.C.S., 4 St Catherine's Place *Councillor*
1889 Gibson, J. D., ordained surveyor, 60 Frederick Street
1908 Gibson, John, Ph.D., F.R.S.E., Professor of Chemistry, Heriot-Watt College
1908 Gibson, Geo. A., M.D., Sc.D., LL.D., 3 Drumsheugh Gardens
1887 *Gilmour, George, builder, 19 Rosslyn Crescent
1907 Given, Ralph D., 10 Ashburnham Road, Bedford
1857 *Gordon, Alexander. (No address)
1851 *Gordon, James Newall, London
1860 *Gray, Rev. W. H., M.A., D.D., 3 Carlton Terrace
1907 Gray, Francis W., 143 Leith Walk
1908 Gray, James, M.I.Mech.E., 47 Polwarth Gardens
1907 Greig, David, Elderslie, Cluny Drive
1893 *Grieve, George K., 12 Cambridge Avenue
1907 Gulliver, G. H., B.Sc., The University, Edinburgh

1860 *Hardie, Walter, 5 Bellevue Street
1888 *Harris, William A., F.S.S., F.I. Inst., secretary, Phœnix Fire Office, Exchange, Liverpool
1870 *Hartnell, Wilson, engineer, Volt Works, Leeds

1879 *Heath, Thomas, F.R.S.E., assistant observer, Royal Observatory
1891 *Herdman, G. W., M.A., B.Sc., Assoc. M. Inst. C.E., Public Works Department, P.O. Box 439, Pretoria
1898 Herring, W. R., M. Inst. C.E., Granton House, Granton, *Vice-President*
1871 *Hislop, George Robertson, F.C.S., gas engineer, Blackstone Road, Paisley
1898 *Hislop, Laurence, gas engineer. Uddingston
1894 Hislop, R. G., 11 Pitt Street
1863 *Hogue. D. W., M.D., dentist, Roxburgh, Marlborough Road, Bournemouth
1906 Horne, Alex. R., B.Sc., Heriot-Watt College
1900 *Horne, Wm. James, A.M.I.E.E., Technical Education Office, The Education Department, Pretoria, Transvaal
1900 Horsburgh, E. M., M.A., B.Sc., F.R.S.E., 11 Granville Terrace
1868 *Horsburgh, John, Aberdour House, Aberdour
1893 Horsburgh, J. Alfred, photographer, 4 West Maitland Street
1906 Houston, Wm. Campbell, B.Sc., Heriot-Watt College
1876 *Hutchison, James T., 12 Douglas Crescent

1882 *Inglis, John William, F.R.S.E., M.Inst. C.E., 26 Pitt Street

1884 *Jenkinson, Alexander Dixson, glass manufacturer, 10 Princes Street
1908 Johnston, Jas. Yate V., C.E., patent agent, 10 Western Terrace
1905 *Jordan, John, merchant, 17 Charlotte Square

1905 Keiller, J. D., scientific instrument maker, 1 Albion Road
1904 Kemp, Charles N., Ivy Lodge, Trinity
1872 *Kemp, D. William, Ivy Lodge, Trinity
1872 *Key, William, St Cyr, Ceres, Fife
1902 Kirkwood, Alexander, 9 St James Square, *Medallist*
1898 Knoblauch, Louis, merchant, 22 Baltic Street, Leith
1887 *Knox, Patrick, plumber, 31 Crichton Place

1902 Laurie, A. P., M.A., D.Sc., F.R.S.E., Principal, Heriot-Watt College, *Vice-President*
1904 *Leslie, James, C.E., 5 Douglas Gardens
1873 *Lewis, David, Roselea Villa, Grange
1906 Linton, Walter, Assoc. M. Inst. C.E., 7 Coatbridge Terrace
1877 *Lockie, John, engineer, 2 Commercial Street, Leith

1904 Macadam, Stevenson, F.I.C., F.C.S., 55 York Place
1882 *Macdonald, James, plumber, 3 Dundas Street
1889 *Macdonald, The Right Hon. Sir J. H. A., K.C.B., LL.D., F.R.S.S. (L. & E.), M.I.E.E., Lord Justice-Clerk of Scotland, 15 Abercromby Place
1898 M'Gregor, Walter, accountant, 32 York Place
1898 M'Hardy, Lieut.-Col. A. B., C.B., 3 Ravelston Park
1888 *Mackenzie, A. Donald, 14 Greenhill Park
1905 Mackenzie, Lachlan P., ironfounder, 5 Polwarth Terrace, *Councillor*
1867 *Maclagan, R. Craig, M.D., F.R.S.E., 5 Coates Crescent
1886 *Martin, William James, C.E., Rosario de Santa Fé, S. America
1884 *Massie, James, M. Inst. C.E., 20 Tantallon Place, *Councillor*
1876 *Mather, Edward, Orwell Works, Dalry Road
1881 *Maxwell-Müller, R. W., C.E.

1863 *Menzies, Duncan, C.E., 39 York Place
1907 Menzies, John, 46 Murrayfield Gardens
1858 *Mercer, James Tod, advocate
1879 *Milne, James, Muirend, Colinton
1907 Milne, John, Muirend, Colinton
1908 Milne, James R., D.Sc., F.R.S.E., 56 Manor Place
1908 Milne, John R., Elderscroft, Peebles
1888 *Mitchell, James D., 45 Hanover Street
1889 *Moncrieff, D. Scott, W.S., 28 Rutland Square
1872 *Morrison, James, City of Glasgow Improvement Trust, 98 Sauchiehall Street, Glasgow
1866 *Muir, W. J. Cockburn, C.E.

1906 Newington, Frank A., M.Inst.C.E., M.I.E.E., 4 Osborne Terrace
1874 *Noble, William, millwright, 27 Rosebank Cottages

1902 O'Connor, Henry, Assoc. M. Inst. C.E., F.R.S.E., P. Pres. Soc. Eng., 1 Drummond Place
1898 Ogilvie, Alexander, B.Sc., electrical engineer, Leith Electric Works, *Councillor*
1889 Ogilvie, F. Grant, M.A., B.Sc., F.R.S.E., 15 Evelyn Gardens, London, S.W.
1904 Omit, Thomas, 15 Torphichen Place

1885 *Paterson, Oscar, glass stainer, 118 West Regent Street, Glasgow
1904 Pilkington, Basil A., electrical engineer, 12 Atholl Place
1882 *Pirie, James, C.E., 135 George Street
1878 *Proctor, Thomas Rodger, 21 West Maitland Street
1864 *Proudfoot, David C., 121 Forest Avenue, Aberdeen
1908 Proven, George, C.E., 2 Commercial Street, Leith
1896 Purvis, George Carrington, M.D., Grahamstown, Cape Colony

1894 Readman, James B., D.Sc., F.R.S.E., Staffield Hall, Kirkoswald, R.S.O., Cumberland
1902 Reis, Alphonse Louis, F.S.M.C., ophthalmic optician, The Laurels, Bright's Crescent, *Councillor*
1890 *Ritchie, Charles, S.S.C., 37 Royal Terrace
1866 *Ritchie, Jas., M.R.C.S., M.B., C.M., 22 Charlotte Square
1896 Ritchie, James, clockmaker, 25 Leith Street
1907 Robertson, William, M.D., 11 Denham Green Terrace, Trinity
1857 *Rollo, Right Hon. Lord, Duncrub House, Bridge of Earn
1908 Romanes, George, B.Sc., 20 Queen Street
1906 Roxburgh, J. F., W.S., 25 Walker Street
1875 *Russell, Sir J. A., M.A., M.B., F.R.S.E., Woodville, Canaan Lane

1867 *Sanderson, William, rectifier, Talbot House, Ferry Road
1878 *Scott, David A., S.S.C., 20 St Andrew Square
1900 Scott, J. Gray, A.I.E.E., Hong-Kong
1908 Shearer, William, Ferniecot, Abbey Road, Dalkeith
1893 *Shiells, C. J., C.A., 141 George Street, *Treasurer*
1883 *Shiells, Henry Kenward, C.A., 141 George Street
1902 Smith, John, engineer, Penicuik
1895 *Smith, J. Ciceri, Raymond House, 32 Theobalds Road, London, W.C.
1877 *Smith, J. Turnbull, C.A., LL.D., Cragside, North Berwick
1904 Somerville, James A., engineer and shipbuilder, Glenesk Crescent, Dalkeith
1889 Stanfield, Richard, F.R.S.E., M. Inst. C.E., M.I.M.E., Professor of Engineering, Heriot-Watt College, *Secretary and Editor of Transactions*

1850 *Stark, James, M.D., F.R.C.P., F.R.S.E. (No address)
1879 *Steuart, Robert Bromfield, C.E. (No address)
1908 Steven, Thomas C., 30 Dudley Avenue, Leith
1896 Stevenson, Alexander, North British Distillery
1881 *Stevenson, Charles Alexander, B.Sc., F.R.S.E. Edin., 28 Douglas Crescent
1879 *Stevenson, David Alan, C.E., B.Sc. Edin., F.R.S.E., 84 George Street
1884 *Stevenson, Peter, instrument maker, 14 Seton Place
1857 *Sturrock, John, Peffermill House, Liberton
1899 Sutherland, Charles S., 54 Morningside Road

1876 *Taylor, William, M.D., 12 Melville Street
1860 *Thomson, Alex., teacher, 40B George Square
1883 *Thomson, Gilbert, C.E., 164 Bath Street, Glasgow
1906 Thomson, Jas., C.E., 17 E. Pier Street, Bo'ness
1878 *Thorburn, William, builder. (No address)
1894 *Turnbull, William James, 16 Grange Terrace
1892 Turner, Dawson, M.D., F.R.S.E., 37 George Square

1882 *Waldie, David, coal merchant, 25 Douglas Crescent
1892 Walmsley, R. M., D.Sc., F.R.S.E., 23 Hilldrop Road, Camden Road, London, N.
1856 *Waterston, George, 10 Claremont Crescent
1892 *Watson, James, M. Inst. C.E., Town Hall, Bradford
1905 Watson, William Pryde, electrician, 35 Elliott Road, Calcutta
1892 Wemyss and March, The Right Hon. The Earl of, Gosford House, Aberlady
1879 *Westland, David Monro, M. Inst. C.E., 135A George Street
1908 Westergaard, Emil, Ph.D., 7 Abbotsford Park
1861 *Whimster, T., gas engineer, 17 York Place, Perth
1879 *White, John, C.E., 17 E. Claremont Street, *Councillor*
1884 *Whyte, Peter, M. Inst. C.E., superintendent, Leith Docks, 4 Magdala Crescent
1877 *Wilkins, Samuel B., 38 Wellington Street, Portobello
1898 Wilson, Andrew, Assoc. M. Inst. C.E., 51 Queen Street, *Councillor*
1898 Wilson, Archibald, A.M.I.E.E., electrical engineer, Leith Electric Works
1859 *Wyllie, James S., 21 Barnton Terrace

1890 *Yooll, W. Graham, oil refiner, 45 Stirling Road, Trinity, *Councillor*
1893 *Young, Robert, 3 Abbotsford Park.

TOTAL ORDINARY FELLOWS, 202.

Associate

1902. Hunter, James, engineer, 23 Craigmillar Park.

CONTENTS OF PART II.—VOLUME XVIII.

PAGE

On a Drawing Office Cabinet for the Supply of Paper, etc., from Rolls. (Illustrated.) By James Gray, M.I.Mech.E. . 117

On Improvements in Means for Preventing or Counteracting Back-lash in Gearing. (Illustrated.) By Dr James R. Milne, F.R.S.E. 122

On the Microscopic Structure of Metallic Alloys. By G. H. Gulliver, B.Sc., F.R.S.E., A.M.I.Mech.E. 124

On Recent Developments in Motor Traction. By The Right Hon. Sir J. H. A. Macdonald, K.C.B., LL.D., F.R.SS. (L. & E.), M.I.E.E., Lord Justice-Clerk of Scotland . . 131

On Arsenic-Free Gas-Coke. By Henry O'Connor, F.R.S.E., and Dr Thos. W. Drinkwater, F.R.S.E. 144

On Direct Colour-Photography by the Lumière Process. By Edward Lumsden Brown 154

On a Magnetic Clutch. (Illustrated.) By W. E. Townsend . 157

APPENDICES.

(A) Proceedings of the Royal Scottish Society of Arts, Session 1907-1908 (being the 87th Session) 1

(B) Report of the Committee appointed to award Prizes for Communications read or reported on during the Session 1907-1908 10

(C) List of Prizes offered by the Royal Scottish Society of Arts for Papers which may be submitted during the Session 1908-1909 12

(D) Abstract of the Accounts of the Society for 1906-1907 . 15

(E) List of the Office-Bearers and Fellows of the Royal Scottish Society of Arts for Session 1908-1909 . . 19